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NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. SUNSET LAKE DAM (DE-00046). CHRIST--ETC(U)
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CHRISTINA RIVER BASIN
UDDY RUN, NEW CASTLE COUNTY
DELAWARE

SUNSET LAKE DAM

DE 00046

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PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

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Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

February, 1979

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE-2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-D

21 MAY 1979

Honorable Pierre S. DuPont
Governor of Delaware
Dover, Delaware 19901

Dear Governor DuPont:

Inclosed is the Phase I Inspection Report for Sunset Lake Dam in New Castle County, Delaware which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Sunset Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 57 percent of the Spillway Design Flood -SDF- would overtop the dam. (The SDF, in this instance, is the 100 year Flood). To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within six months from the date of approval of this report, engineering studies and analyses should be initiated to determine the spillways foundation condition and structural stability. This should include subsurface investigations to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. Within 30 days from the date of approval of this report additional stone armor should be placed on the splashpad fronting the stone wall overflow structure to prevent further undermining of the wall.

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Honorable Rierre S. DuPont

d. Within six months from the date of approval of this report the 18-inch diameter low level outlet should be restored to full operational use, i.e., the valve should be able to be opened or closed without use of a lever device.

e. Within one year from the date of approval of this report a system of annual inspection visits should be initiated using a visual check list similar to the one enclosed in this report. All drawings and computations relating to repair, renovation and maintenance of the dam for operation and maintenance should be logged in as a matter of record.

A copy of the report is being furnished to Mr. Austin P. Olney, Delaware Department of Natural Resources and Environmental Control, the designated State Office contact for this Program. Within five days of the date of this letter, a copy will also be sent to Congressman Thomas B. Evans. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

1 Incl
As stated

J. G. TON
JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Copies furnished:
Mr. Austin P. Olney, Secretary
Department of Natural Resources and
Environmental Control

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SUNSET LAKE DAM (DE00046)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 26 October 1978 by Thomas Tyler Moore and Lippincott Engineering Associates, joint venture under contract to the U. S. Army Engineer District, Philadelphia, in accordance with the National Dam Inspection Act, Public Law 92-367.

Sunset Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 57 percent of the Spillway Design Flood -SDF- would overtop the dam. (The SDF, in this instance, is the 100 year Flood). To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within six months from the date of approval of this report, engineering studies and analyses should be initiated to determine the spillways foundation condition and structural stability. This should include subsurface investigations to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. Within 30 days from the date of approval of this report additional stone armor should be placed on the splashpad fronting the stone wall overflow structure to prevent further undermining of the wall.

d. Within six months from the date of approval of this report the 18-inch diameter low level outlet should be restored to full operational use, i.e., the valve should be able to be opened or closed without use of a lever device.

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e. Within one year from the date of approval of this report a system of annual inspection visits should be initiated using a visual check list similar to the one enclosed in this report. All drawings and computations relating to repair, renovation and maintenance of the dam for operation and maintenance should be logged in as a matter of record.

APPROVED: 

JAMES G. TON

Colonel, Corps of Engineers
District Engineer

DATE: 21 May 79

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

NAME OF DAM - Sunset Lake Dam ID # DE 00046

STATE LOCATED - Delaware

COUNTY LOCATED - New Castle

**STREAM - Muddy Run Tributary
Christina River**

DATE OF INSPECTION - 26 October 1978

Brief Assessment of General Condition:

Based on visual inspection, available records, calculations and past operational performance, Sunset Lake Dam is considered to be in fair overall condition. However, a portion of the overflow structure consisting of a stone wall fronted by earth fill is considered structurally inadequate since most of the mortar bonding the stone together has deteriorated and is almost non-existent. The existing spillway has a hydraulic capacity equal to 56% of the 100 year flood before the low point of the earthen embankment is overtopped, and is therefore considered hydraulically inadequate.

To insure adequacy of the structure, the following actions are recommended:

- 1) Additional stone armor should be placed on the splashpad fronting the stone wall overflow structure to prevent further undermining of the wall. This action should be initiated immediately.

**PHASE I REPORT
SUNSET LAKE DAM ID # DE 00046**

- 2) **Engineering and subsurface investigations to determine the structural stability of the deteriorated stone wall overflow structure should be initiated very soon. This study should be completed and any recommended construction begun soon.**
- 3) **A further study should be initiated very soon to study the feasibility of increasing the hydraulic capacity of the spillway. The study should be completed and any recommended construction should begin.**
- 4) **The 18-inch diameter low level outlet should be restored to full operational use i.e., the valve should be able to be opened or closed without use of a lever device. This should be done soon.**
- 5) **An annual inspection visit should be initiated using a visual check list similar to the one enclosed in this report.**

All drawings and computations relating to repair, renovation and maintenance of the dam should be kept as a matter of record. All visits to the dam for operation and maintenance should be logged in as a matter of record.

MOORE & LIPPINCOTT - ENGINEERS

Thomas Tyler Moore
**Thomas Tyler Moore, P.E.
Project Manager**



OVERALL VIEW
OF
CONCRETE OVERFLOW DAM

OCT. 26, 1978

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PLATES

**LOCATION MAP
AERIAL PHOTO
PLAN, SECTIONS, & PROFILE OF DAM
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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigation, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test

flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

**PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: SUNSET LAKE DAM**

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. **Authority** - The Dam Inspection Act, Public Law 92-367, dated August 8, 1972, provides for the report herein. The inspection of Sunset Lake Dam was initiated under Contract DACW61-79-C-006 with the Department of the Army, Philadelphia District, Corps of Engineers by the engineering firms of Thomas Tyler Moore and Lippincott Engineering Associates under a joint venture.
- b. **Purpose of Inspection** - The purpose of the inspection is to evaluate the general condition of Sunset Lake Dam and bring to the attention of the owner those conditions which are a hazard to the public. The National Inventory of Dams will be updated by the data accumulated during this inspection.

1.2 DESCRIPTION OF PROJECT

- a. **Description of Dam and Appurtenances** - Sunset Lake Dam consists of an overflow structure located between two earth-fill embankment dams. The overflow structure consists of an existing stone gravity dam fronted by earth fill and a newer concrete gravity overflow dam which was constructed to act as the main spillway. The crest of the concrete

NAME OF DAM: SUNSET LAKE DAM

gravity structure is nine inches lower than the crest of the stone embankment structure. The embankments on either side of the overflow dams are approximately five feet higher in elevation at their crest than the crest of the overflow dam. A low level 18" diameter pipe with headwall and gate valve is located in the east embankment.

Sunset Lake varies in depth, but soundings taken during our survey indicate a maximum depth of ten feet, six inches upstream of the new concrete spillway.

Sunset Lake extends 5,000 feet upstream of the dam axis. The banks of the lake are low sloping and well vegetated.

A highway bridge and a railroad embankment exist immediately downstream of Sunset Lake Dam. The highway bridge deck is located approximately one foot below the normal lake elevation and the effective area below the concrete beams and between abutments is approximately 390 square feet. The crest of the rail embankment is located approximately twenty-three feet above normal lake elevation and the effective area of the culvert through the embankment is 460 square feet. Immediately downstream of the railroad embankment is a trailer park. The trailer park at its closest location is located not more than fifty feet from the edge of the bank. A portion of the park is lower than normal lake elevation by as much as two feet but appears to be approximately 15 feet above the downstream channel at this location.

NAME OF DAM: SUNSET LAKE DAM

- b. Location - Sunset Lake Dam is located on a tributary known as Muddy Run approximately 9,000 feet upstream of its confluence with the Christina River in New Castle County, Delaware. Sunset Lake Dam is also approximately three miles upstream of Smalleys Pond and Dam.
- c. Size Classification - The maximum height of the dam is fifteen feet (West Embankment). The maximum reservoir volume is 553 acre-feet. Therefore, the size category of the dam is "Small", i.e., the height is less than forty feet and the storage volume is less than 1,000 acre-feet.
- d. Hazard Classification - Immediately downstream of Sunset Lake Dam exists a low-lying two-lane state roadway (Route 72) leading to the city of Christiana. In our judgment, failure of the dam would result in the possible loss of a few lives. Therefore, Sunset Lake Dam is considered a Significant Hazard Dam.
- e. Ownership - Newark Anglers Association
P.O. Box 54
Newark, Del. 19711
- f. Purpose of Dam - The purpose of the dam is to impound water for recreational purposes. The prime activity in the lake is fishing.

NAME OF DAM: SUNSET LAKE DAM

1.3 PERTINENT DATA

a. Drainage Area - 8.2 square miles.

b. Discharge At Damsite - Maximum known flood at damsite is unknown.

Warm water outlet at pool elevation:	None
Diversion tunnel low pool outlet at pool elevation:	N/A
Low-level outlet at normal pool elevation:	23 cfs
Diversion tunnel outlet at pool elevation:	N/A
Gated spillway capacity at pool elevation:	N/A
Gated spillway capacity at maximum pool elevation:	N/A
Ungated spillway capacity at maximum pool elevation:	4000 cfs
Total spillway capacity at maximum pool elevation:	4000 cfs
Total spillway capacity at top of dam:	2110 cfs

c. Elevation (feet above Mean Sea Level (M.S.L.)) -

Top Dam:	39.9 ft. M.S.L. Minimum
Maximum pool-design surcharge:	41.6 ft. M.S.L.
Full flood control pool:	N/A
Normal Pool:	36 ft. M.S.L. \pm
Spillway Crest:	36.0 & 36.75
Upstream portal invert diversion tunnel:	N/A
Downstream portal invert diversion tunnel:	N/A

NAME OF DAM: SUNSET LAKE DAM

Streambed at centerline of dam:

25.9 ft. M.S.L.

Maximum tailwater:

Tailwater at high stream discharge probably will be controlled by a culvert under Rt. 72 and the bridge through the railroad embankment

d. Reservoir (feet) -

Length of Maximum Pool - 8500 feet

Length of Normal Pool 5000 feet

Length of Flood Control Pool - N/A

e. Storage (acre-feet) -

Normal Pool - 147

Flood Control Pool - N/A

Top of Dam - 400

Maximum Pool - 590

f. Reservoir Surface (acres) -

Normal Pool - 44

Top of Dam - 89

Flood Control Pool - N/A

Maximum Pool - 115

Recreational Pool - N/A

g. Dam -

Type - Earth-fill embankments and concrete/stone overflow (spillway)

Length - 375 feet of earth-fill, 110 of concrete/stone overflow (spillway)

Height - Existing embankment & earth fill - 15+
Concrete/Stone overflow - 10.5

NAME OF DAM: SUNSET LAKE DAM

Top Width - Earth-fill = 5'+ at western side
 40'+ at eastern side, varies considerably
 New Concrete overflow - 2.3'
 Old Stone Overflow - 4.0'

Side Slopes Western End (Earth-fill) - Approx. 1.7 to 1 upstream and downstream; below normal pool 3.3 to 1

Eastern End - Approximately 2.2 to 1 downstream, averages 8.1 upstream; below normal pool 3.3 to 1

Impervious Core: Unknown
 Cutoff: Unknown
 Grout Curtain: Unknown

h. Spillway -

Type - Overflow dam
 Length of Weir - 87 feet interrupted by 23 foot retaining wall

Crest Elevation - Stepped overflow, varies between 35.86 feet and 36.85 feet M.S.L.

Gates - None

Upstream Channel - Lake

Downstream Channel - Open channel with few sloping vegetated banks

- i. Regulating Outlets -** A low-level, gated, 18" diameter diameter reinforced concrete pipe, 50+ in length, extending through the east embankment. Valve is submerged. Stem extends to embankment.

- j. Design & Construction -** The present spillway structure consists of an old 34-foot long flat crested weir spillway and a recently constructed 53-foot gravity retaining structure with a spillway separated by a 23-foot long concrete retaining wall. It could not be determined when the original spillway structure was built, but it is apparent that the original structure was inadequate so a subsequent structure was built to increase the normal spillway capacity.

NAME OF DAM: SUNSET LAKE DAM

No drawings or design data were available, however, from conversations with members of the Newark Anglers Association, design work may have been performed by local college professors within the last 15 years.

NAME OF DAM: SUNSET LAKE DAM

SECTION 2 - ENGINEERING DATA

Engineering data in the form of computations or drawings are unavailable. Specific items required to determine the safety of the dam are listed in paragraph 7.1.b.

NAME OF DAM: SUNSET LAKE DAM

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General - Sunset Lake Dam was found to be in fair overall condition at the time of inspection with the exception of the stone/earthfill overflow dam. This old overflow structure does not appear adequate to sustain a significant amount of overflow nor the turbulence which would develop from large volume overflow.

b. Dam

Earthfill - No visible signs of movement either vertically or horizontally were evident. Some erosion of the downstream embankment was noticeable adjacent to the east wingwall of the concrete overflow dam. Substantial excavation along the downstream toe of the west embankment has been made to construct the embankment.

Overflow Dam - Erosion of the embankment supporting the old stone dam structure was evident. However, the crest (spillway portion) of the structure appeared to be intact.

The splash apron below the crest showed significant damage. In general the mortar, bonding the rock apron, was highly deteriorated. Many rocks were loose and of questionable structural value. A portion of the apron was broken off altogether. No toewalk to the apron area appears to have been constructed.

NAME OF DAM: SUNSET LAKE DAM

The concrete gravity dam appears to have been repaired and/or altered in the past. From the grout patchwork prevalent along the downstream face, the height of the structure may have been increased in excess of one foot. The date of "1966" is inscribed in the patchwork. Four (4) concrete "piers" approximately 1.67 to 2.0 feet in width, 4 inches in depth, randomly placed along the downstream face of the spillway, extend the full height of the spillway structure.

At the time of this writing no structural significance could be attributed to these "piers". At the junction of the spillway with the east wingwall massive triangular piers have been placed each side of the wingwall with the apparent purpose of adding stability. Substantial deterioration was noted at the downstream edge of the wingwall (sandwiched between the triangular concrete piers) which may have prompted construction of these triangular piers. Steel reinforcing was not visible within the deteriorated concrete. It appears that both wingwalls have been increased in height by about one foot.

Low Level Outlet - An outlet structure, consisting of an 18" diameter gate equipped with a manually operated valve, exists within the eastern embankment. Inasmuch as the gate was submerged at the time of inspection, the condition of the gate could not be determined. It was

NAME OF DAM: SUNSET LAKE DAM

noted that the extension shaft was bent and the support frame was in poor condition. The control valve, although operable, requires a lever to turn it. Some slight leakage was observed at the discharge pipe (approximately 10 gpm). Such flow would have no detrimental effect.

- c. Appurtenant Structures - There are no appurtenant structures associated with this dam.
- d. Reservoir Area - Only the downstream portion of the reservoir was accessible. All other portions of the reservoir would require access by boat or passage through private property. However, it appeared from the downstream location that sloughing of the heavily vegetated flat bank along the reservoir was not occurring. The amount of silt accumulation was not determined, but judging from the turbidity, substantial siltation could be expected.
- e. Downstream Channel - The spillway overflows onto a twelve-foot wide rock apron which is flanked by the wingwalls extending from the dam spillway. The downstream channel, immediately below the dam spillway, meanders through low mildly-sloping banks with well vegetated deciduous growth. This 30 ft. \pm wide channel travels about 350 ft. before reaching the highway bridge at Route 72. The highway bridge has a hydraulic

NAME OF DAM: SUNSET LAKE DAM

opening approximately ten (10) feet by thirty-nine (39) feet. Just below this bridge is a 35 foot high railroad embankment with a 28.5 by 18 foot arched opening. Below the railroad embankment, owned by Penn Central, the stream channel narrows to about fifteen feet and meanders past Timberlane Mobile Home Park. There appears to be at least one hundred dwellings within the park. At least ten of these dwellings may have been built on fill within the floodway. However, at this location, the floodway is at least 200 feet in width and may be as wide as 400 feet.

f. **Evaluation** -

1. **Spillway** - The stability of the concrete overflow structure and the stone/earth-fill overflow structure will be discussed in Section 7. However, the focus of attention is on the stone wall supporting the earth-fill of the overflow structure, since the structural integrity of the wall is in question.
2. **Embankment** - No visible signs of seepage or instability were noted during inspection. Based on our visual inspection and past performance of the embankment, an evaluation is made in Section 7.
3. **Low Level Outlet** - The significance of the 18" gated outfall is discussed in Section 7.

NAME OF DAM: SUNSET LAKE DAM

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Sunset Lake Dam is operated by the owner's full-time "caretaker", who also maintains the club houses and boats. The lake level is to some extent controlled using the 18" diameter low level gated outlet pipe located in the east embankment. When significant rainfall is anticipated, the outlet gate is opened. The available increase in storage is questionable.

4.2 MAINTENANCE OF DAM

It appears that modifications to the dam have been implemented in the past, but no formal or systematic maintenance program exists at the present time.

4.3 MAINTENANCE OF OPERATING FACILITIES

The wheel and shaft valve regulating the discharge through the 18-inch concrete pipe is repaired when vandals damage it (according to the owner). Thus, maintenance is on an "as needed" basis.

4.4 DESCRIPTION OF A WARNING SYSTEM IN EFFECT

There is no warning system in effect.

4.5 EVALUATION

1. The need for implementation of annual inspections will be discussed in Section 7.

NAME OF DAM: SUNSET LAKE DAM

2. The need for keeping records of construction improvements will be discussed in Section 7.
3. The need for implementation of a warning system will be discussed in Section 7.

NAME OF DAM: SUNSET LAKE DAM

SECTION 5 - EVALUATION OF HYDROLOGIC AND HYDRAULIC FEATURES

5.1 EVALUATION OF FEATURES

- a. Design Data - No design data were available for either the hydrology of the watershed or the capacity of the spillway. For hydrologic evaluation, watershed parameters measured from USGS 7.5 minute quadrangles were used with Snyder coefficients and loss rates specified by the COE to compute peak inflows to the reservoir. The HEC-1 DB computer program was used to compute the inflow hydrograph and perform the flood routing through the lake.

The dimensions of the dam and the spillway were obtained from a field survey. Spillway capacity was calculated from this survey information by standard engineering methods. The relevant data for the highway culvert and the railroad bridge downstream were also measured since these represent restrictions to flow which would control the tailwater at the dam for high flood flows.

Based on the size and hazard potential classification for this dam the recommended spillway design flood is 100 year - $\frac{1}{2}$ PMF. For evaluating the adequacy of the spillway the 100-year flood was used as the SDF.

b. Experience Data

No measurements of outflows from the dam or flows within the watershed of the dam are available. There is a streamflow gaging station .9 miles from the dam on the Christina River, 2.6 miles above Muddy Run.

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This gaging station is USGS Station Number 01478000 - Christina River at Coochs Bridge, Delaware. Based on 34 years of record the maximum recorded discharge was 3320 cfs for a 20.5 mi² watershed.

- c. Overtopping Potential - From the HEC-1 DB program the peak SDF (100-year) inflow = 4254 cfs. The water level in the reservoir would have to reach elevation 41.5 with a peak outflow of 3741 cfs to pass the Spillway Design Flood. This would overtop the low point of the dam embankment by 1.6 feet. The spillway capacity at the top of dam elevation (39.9) is 2110 cfs, which is equal to 56% of the SDF peak outflow. A rating curve for the spillway and a graph summarizing peak inflows and outflows is included in Appendix D.

From approximate calculations the downstream railroad embankment acts as a control section. In order to pass the SDF through the railroad culvert the water level behind the embankment would reach elevation 37.3. However, this will not appreciably reduce spillway capacity. At this flow the highway would be overtopped by approximately 2½ feet.

- d. Emergency Drawdown - The lake can be drawn down by an 18-inch RCP low level outlet controlled by a gate valve. The maximum flow through this outlet is about 23 cfs with the reservoir at elevation 36. Flows of this magnitude would not be significant during peak inflows. With no

NAME OF DAM: SUNSET LAKE DAM

inflow it would take more than 96 hours to drain the reservoir. The current practice is to open the gate valve during rainstorms to prevent the older stone spillway from being overtopped.

NAME OF DAM: SUNSET LAKE DAM

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observations - Except for that portion of the overflow dam consisting of a mortared stone gravity wall fronted by earth fill, no significant structural inadequacies were noted during the inspection of the dam. As noted during our inspection, the mortar bonding the rock together has deteriorated. The splash apron below the gravity wall is seriously deteriorated. The fill in front of the rock gravity wall exhibits signs of erosion. No seepage below or around the spillways was observed. It does not appear that deterioration of the wingwalls poses a structural threat at this time, but it must be repaired to prevent further deterioration.

- b. Design and Construction Data - Stability calculations for the dam do not exist.

Insufficient engineering data is available to make an accurate independent assessment of the earth-fill embankment and overflow dam. Neither accurate engineering drawings nor computations are available.

Predicated upon our field survey information, a preliminary structural assessment of the concrete overflow dam indicates that a safety factor greater than 1.5 exists with respect to overturning and sliding. Calculations were based on survey dimensions and assumed soil parameters. Also, hydraulic loading was taken at water surface elevation 41.6.

NAME OF DAM: SUNSET LAKE DAM

Structural computations for the rock gravity structure were not performed since actual dimensions of the structure were not obtainable. Further deterioration of the downstream apron could promote a toe failure in the structure.

- c. **Operating Records** - Operating records have not been kept for Sunset Lake Dam.
- d. **Post-Construction Changes** - Modifications to the embankment and spillway are evident. The owner stated that the crest height of the west embankment had been raised in recent years. It was also noted that the west wingwall height had been increased to adjust for the change in adjacent embankment height. We believe that the height of the concrete spillway has been increased as well.
- e. **Seismic Stability** - Sunset Lake Dam is located in Zone 1 on the Seismic Zone Map of the United States. Experience has shown that structures having adequate stability under static loading conditions will also have adequate stability under seismic activity. Thus, as previously noted, only that portion of the dam consisting of stone/earth fill overflow is not considered stable under seismic loading.

NAME OF DAM: SUNSET LAKE DAM

SECTION 7 - ASSESSMENT/RECOMMENDATIONS,
PROPOSED REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. **Safety** - The dam has been inspected visually, in accordance with procedures by the Corps of Engineers for a Phase I Report. Since no engineering data was available for review, our assessment is subject to those limitations inherent in a visual inspection.

That portion of the overflow structure consisting of a stone wall fronted by earth-fill is considered structurally inadequate. Significant deterioration of the mortar, bonding the stone together, was noted during inspection. Without this mortar, the stone is held together by friction and this is of small structural value in a retaining wall. The mortar bonding the stone splashway together is also deteriorating. The stones are loose and infrequent, subsequently, erosion is occurring at the base of the wall and throughout the splashway. The erosion at the base of the wall contributes to the undermining of the wall foundation and reduces stability safety factors.

No seepage or slope failures were noted during inspection that would indicate potential piping or embankment failures. According to the owner, no seepage or slope failures have occurred in the past.

No cracking or movement of the concrete portion of the overflow structure was noted during inspection that would indicate potential

NAME OF DAM: SUNSET LAKE DAM

overturning or sliding failures. Calculations based on assumed soil parameters and survey data obtained during inspection indicate safety factors for overturning and sliding greater than 1.5.

- The spillway has a hydraulic capacity equal to 56% of the peak SDF outflow. The low point (see profile) of the earthen embankment will be overtopped by 1.6 feet during the SDF.
- Warning System - Although there is no warning system in effect, the need for a system is not considered necessary since the only homes are downstream of the railroad embankment.
- An annual inspection program is needed so as to enable the owner to notice variations in appearance of specific portions of the dam. It is recommended that the owner use forms similar to the federal visual inspection forms included in this report.
- Accurate construction records should be kept of any modifications or alterations to the dam. This information is needed so as to enable accurate analysis in the future.
- b. Adequacy of Information - Additional information is needed to complete an assessment of the safety of the dam.

To assess the safety of the stone/earth-fill overflow structure, the following data is needed:

NAME OF DAM: SUNSET LAKE DAM

1. Engineering parameters of the soils behind and below the stone/earth-fill overflow structure.
2. Studies to determine the exact extent of mortar deterioration in the stone wall.
3. Studies to determine the strength of existing mortar and stone.
4. Test pits to determine the geometry of the stone wall and foundation type.

c. Urgency -

- Additional stone armor should be placed on the splashpad fronting the stone wall overflow structure immediately.
- Engineering and subsurface investigations to determine the structural stability of the deteriorated stone wall overflow structure should be initiated very soon.
- A further study should be initiated very soon to study the feasibility of increasing the hydraulic capacity of the spillway. This study should be completed and any recommended construction should begin soon.
- The 18-inch diameter low level outlet should be restored to full operational use soon, i.e., the valve should be able to be opened or closed without use of a lever device.

d. Necessity for Additional Data/Evaluation

As demonstrated in Section 7.1 - a. and b., additional data and evaluation is necessary.

NAME OF DAM: SUNSET LAKE DAM

7.2 REMEDIAL MEASURES

a. Alternatives - The following remedial action is recommended:

As part of the further study recommended in Section 7.1 above, regarding increasing the spillway capacity, the following alternatives or combination of alternatives should be considered:

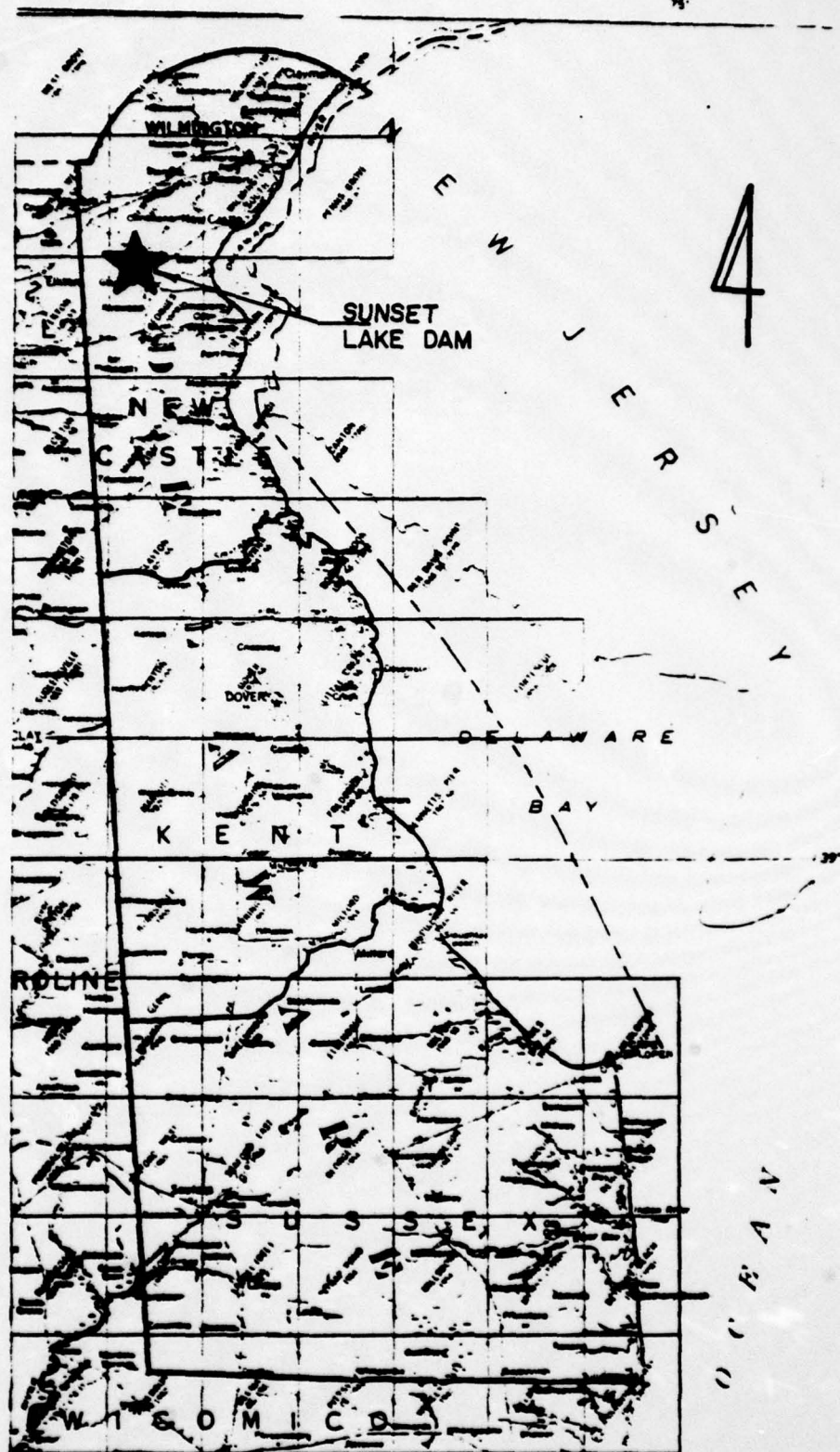
1. Increasing the size of the existing spillway.
2. Raising the elevation of the top of the dam.
3. Armoring low points of the earthen embankment to protect against breach during periods of overtopping.

b. O & M Maintenance Procedures - An annual inspection visit should be initiated using a visual check list similar to the one enclosed in this report.

All drawings and computations relating to repair, renovation and maintenance of the dam should be kept as a matter of record. All visits to the dam for operation and maintenance should be logged in as a matter of record.

NAME OF DAM: SUNSET LAKE DAM

PLATES



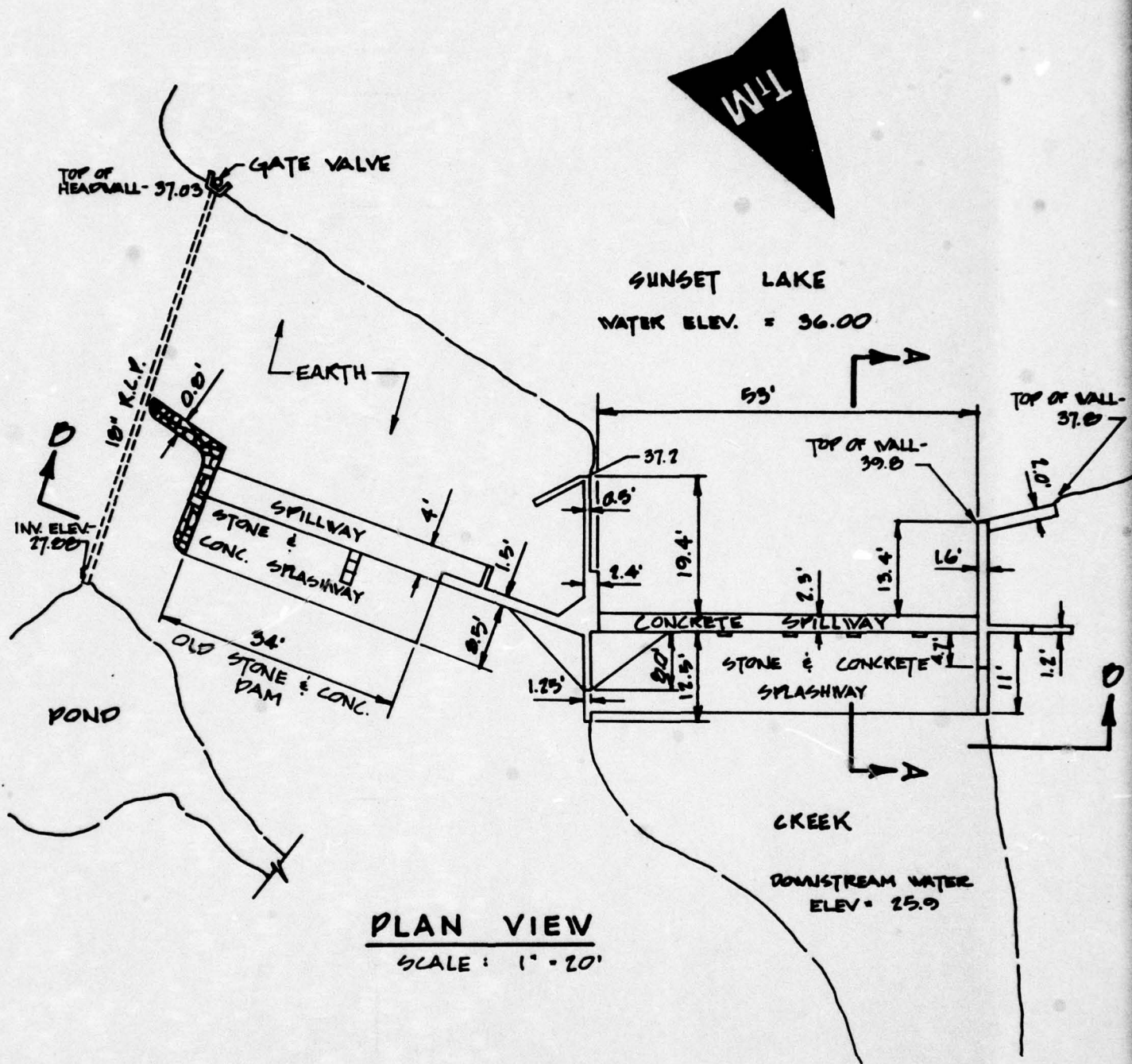
LOCATION MAP

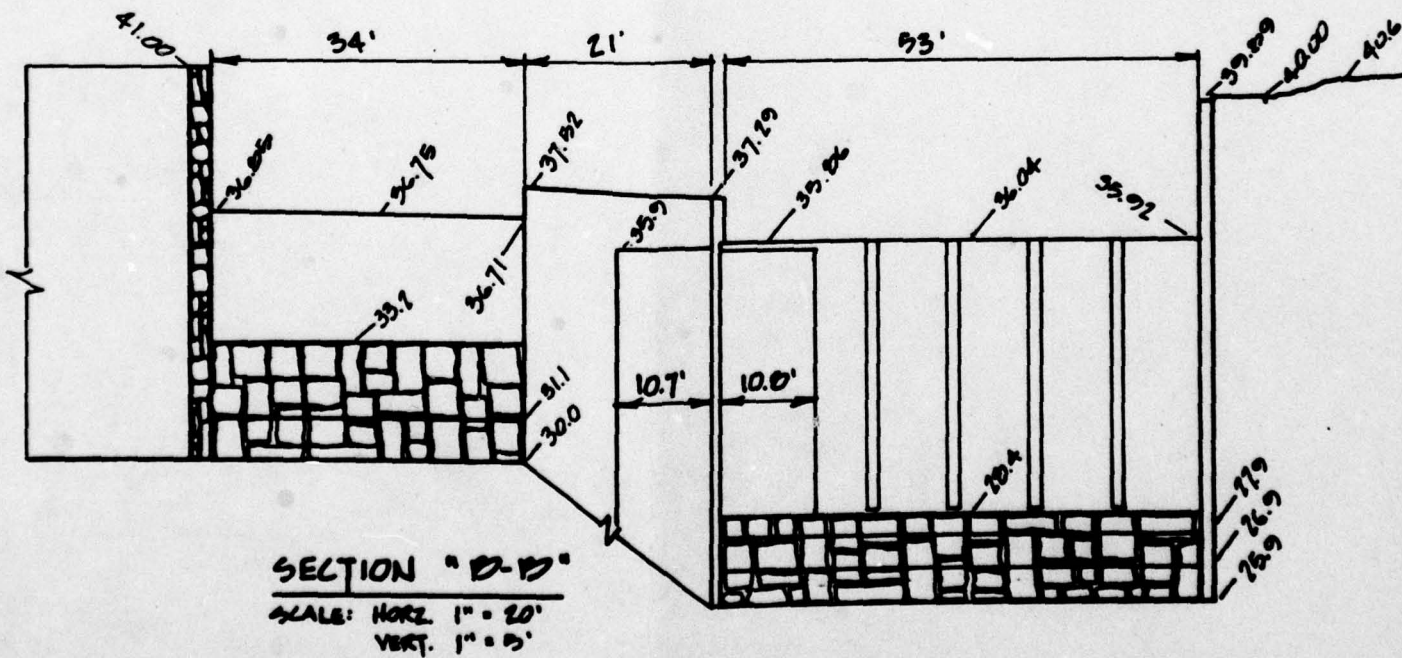
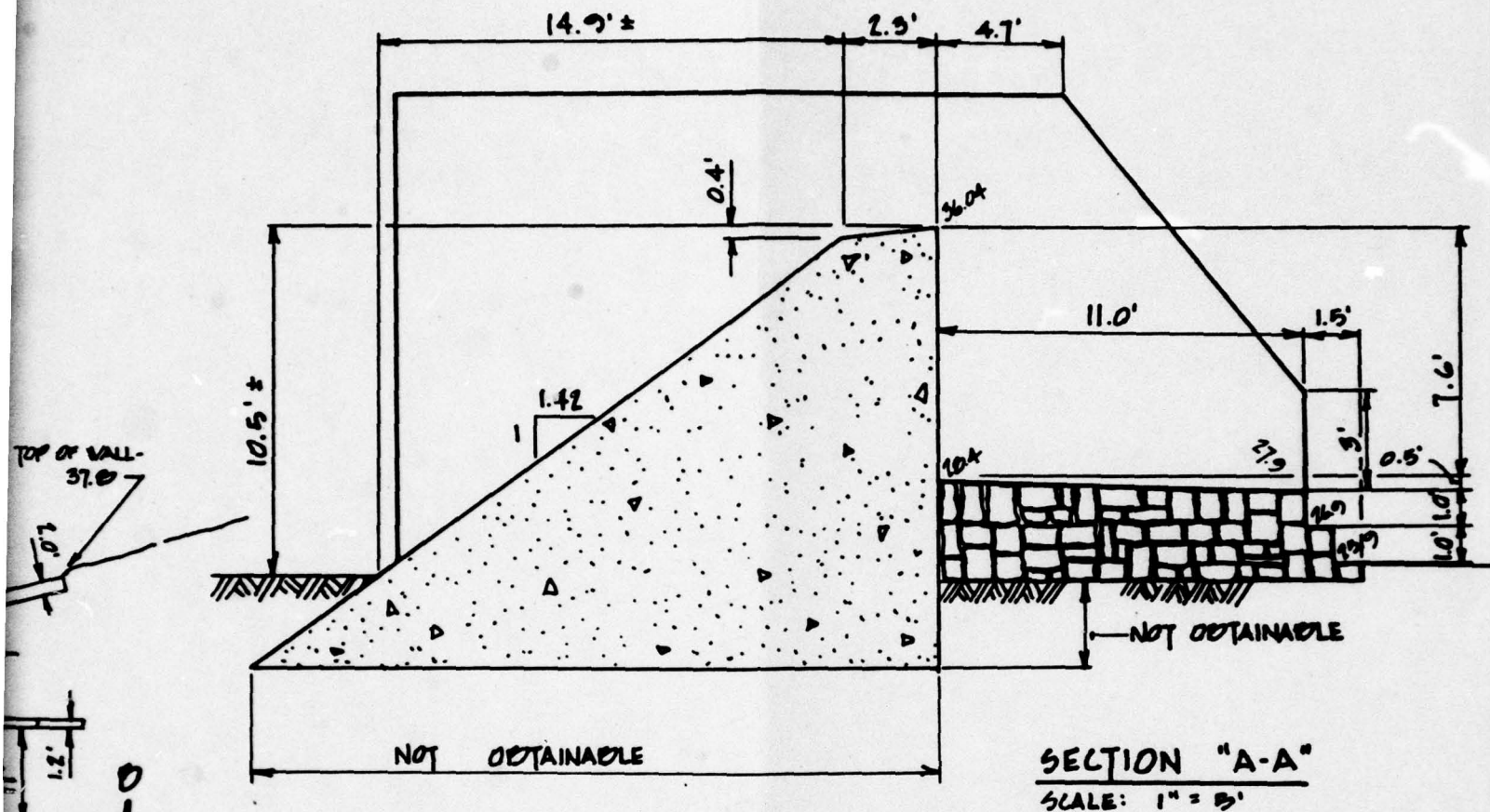
SUNSET LAKE DAM

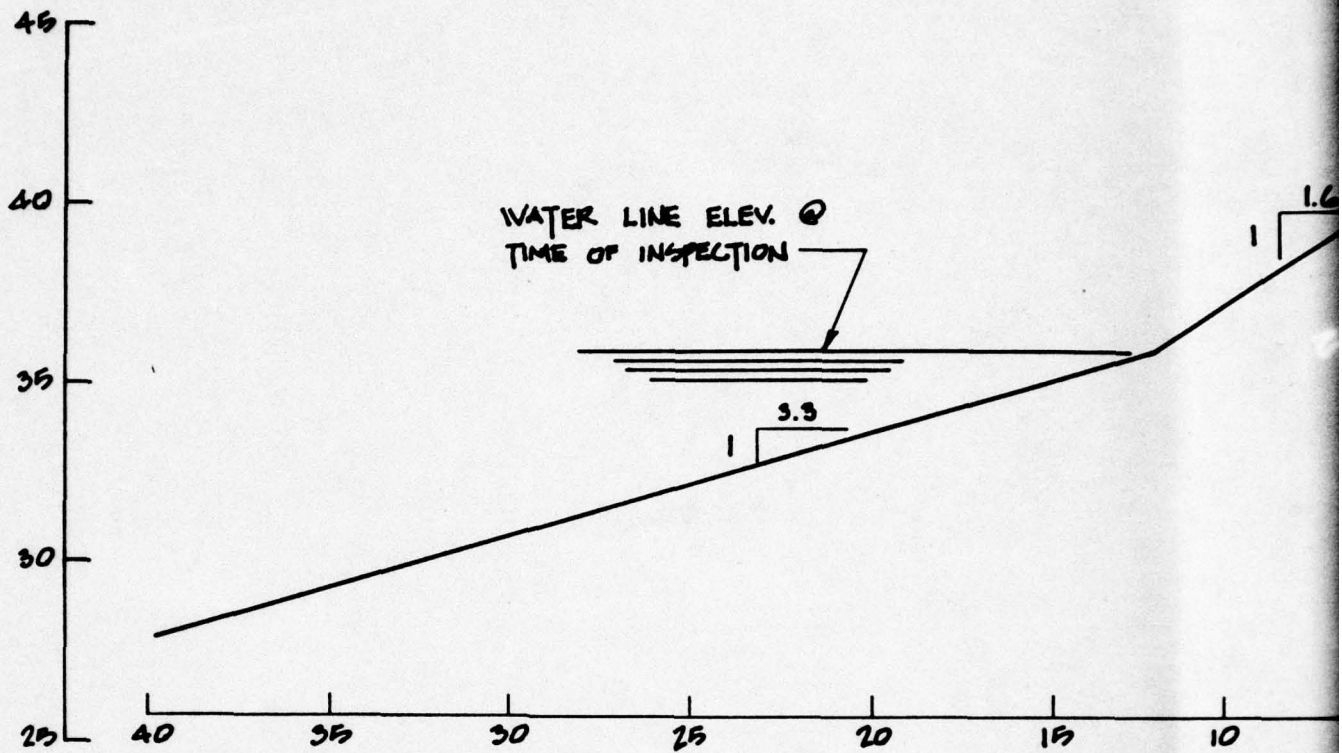


AERIAL PHOTO

PLATE #2

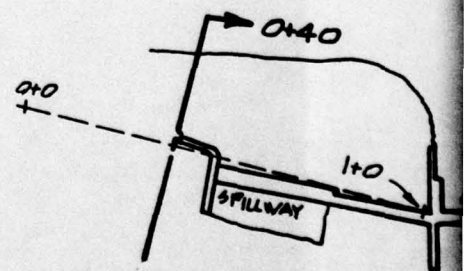




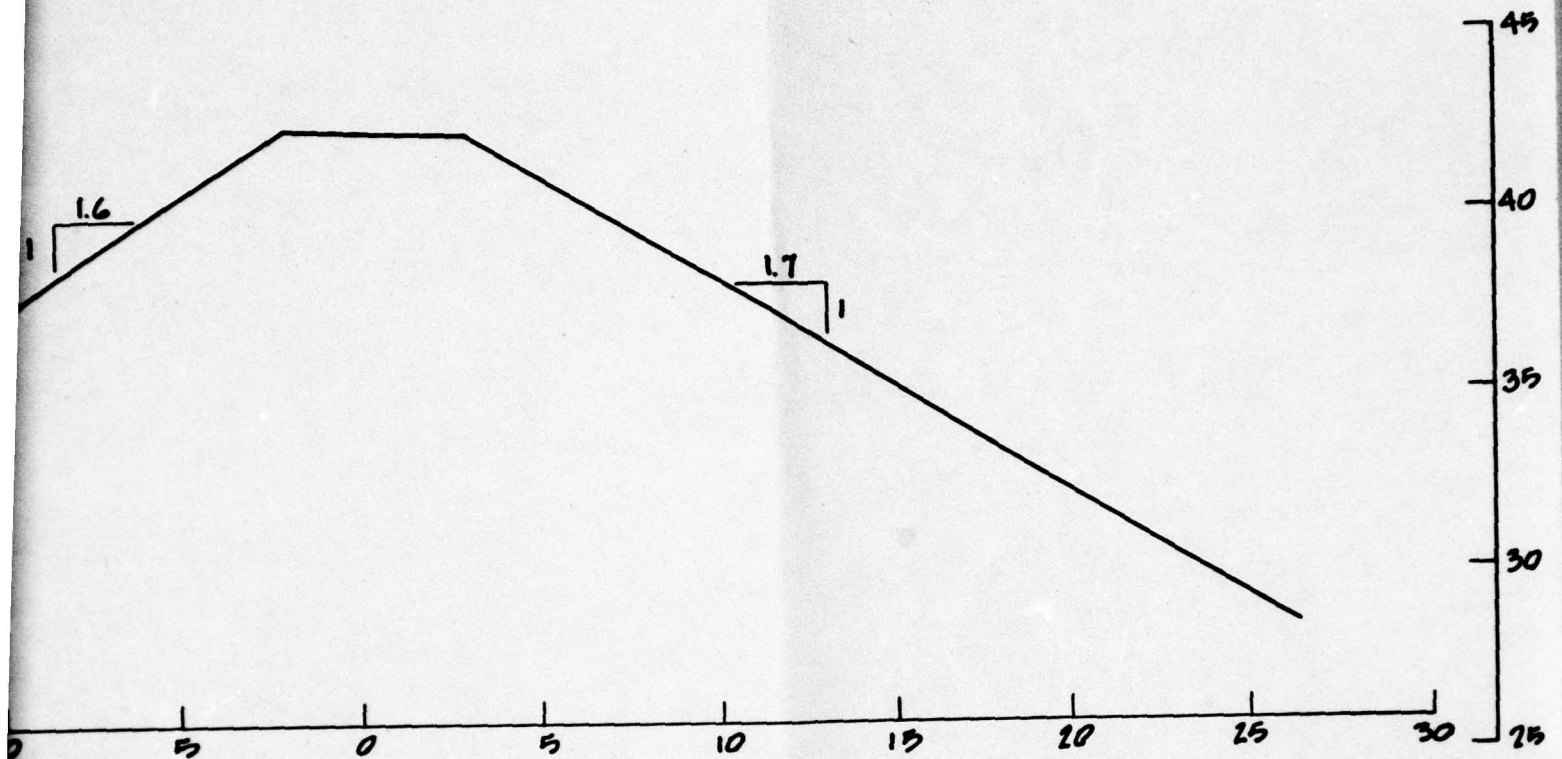


CROSS - SECT

SCALE:

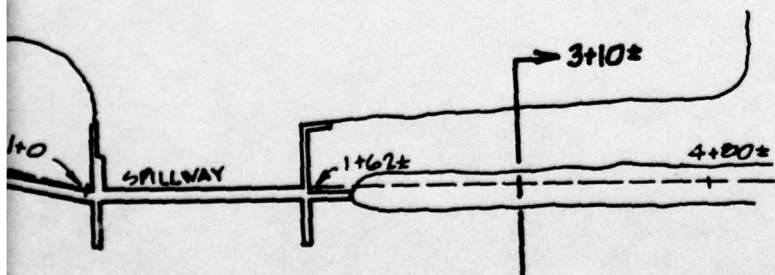


PLAN
SLA



SECTION AT STA. 3+10±

SCALE: HORIZ 1" = 5'
VERT. 1" = 5'

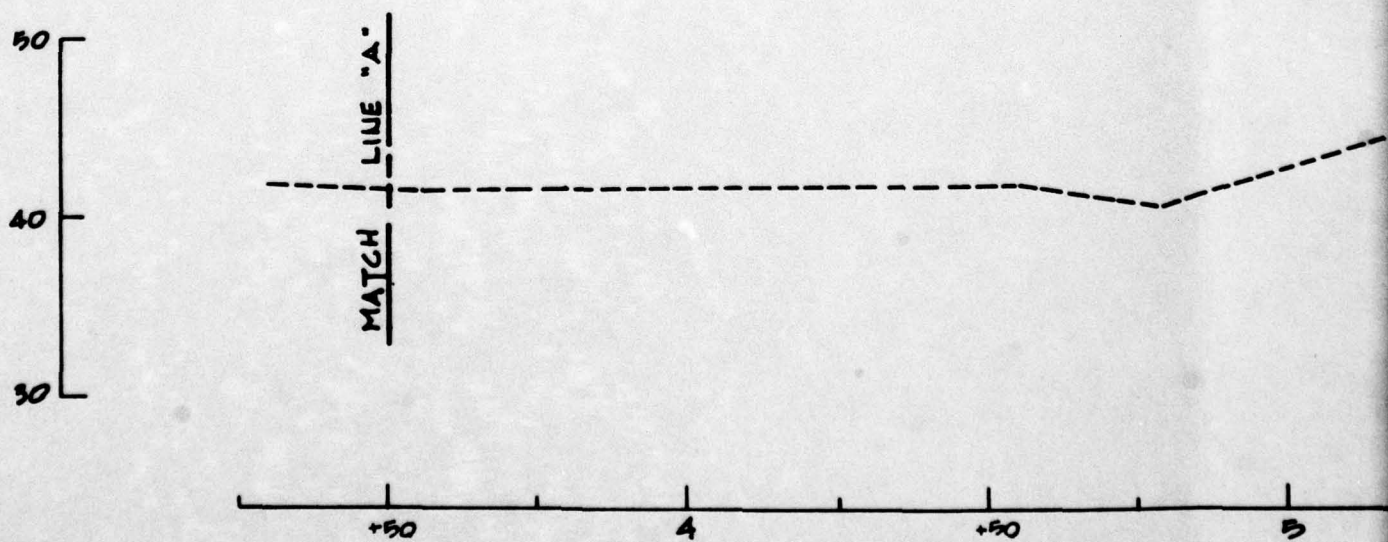
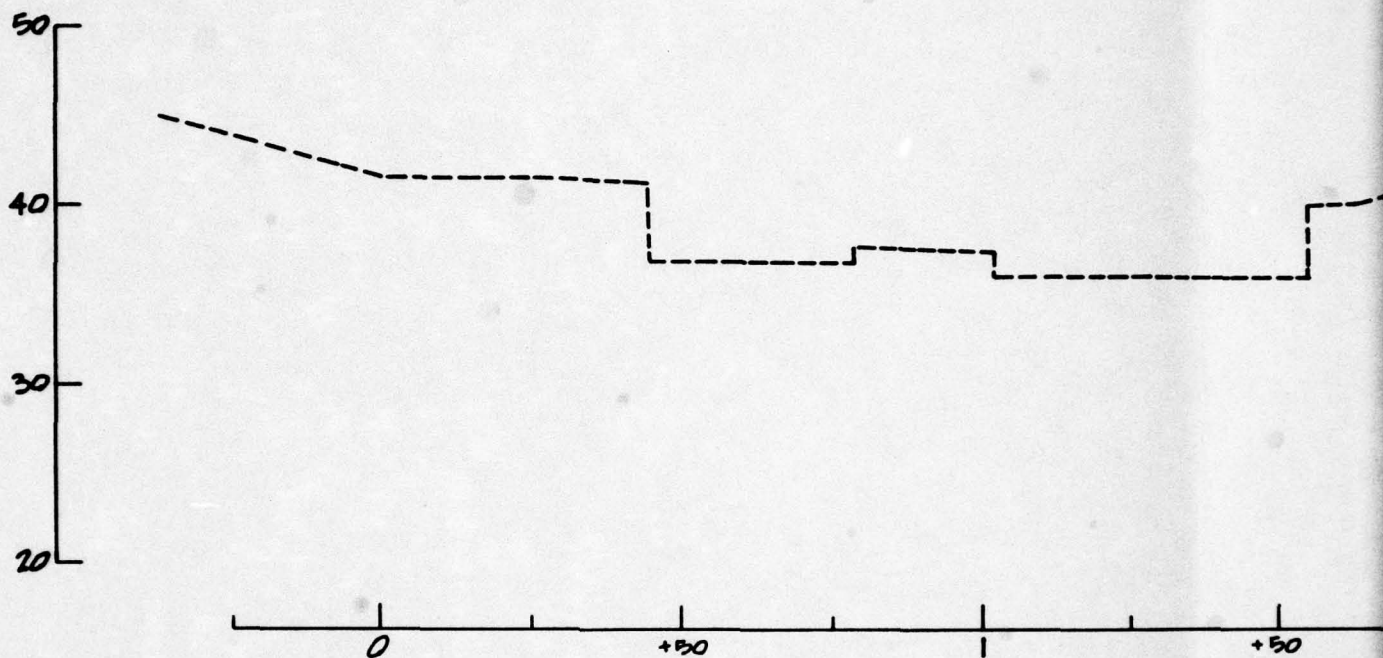


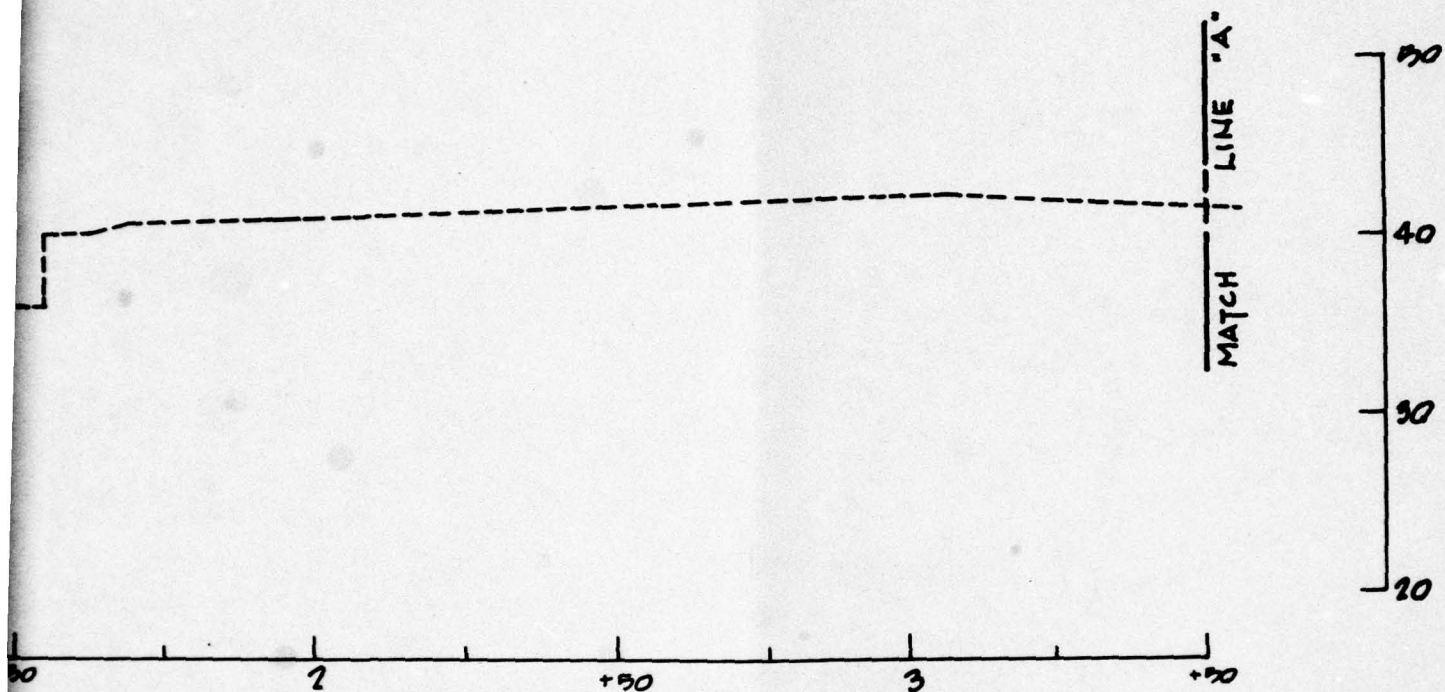
PLAN VIEW

SCALE: NONE

PLATE 4

2



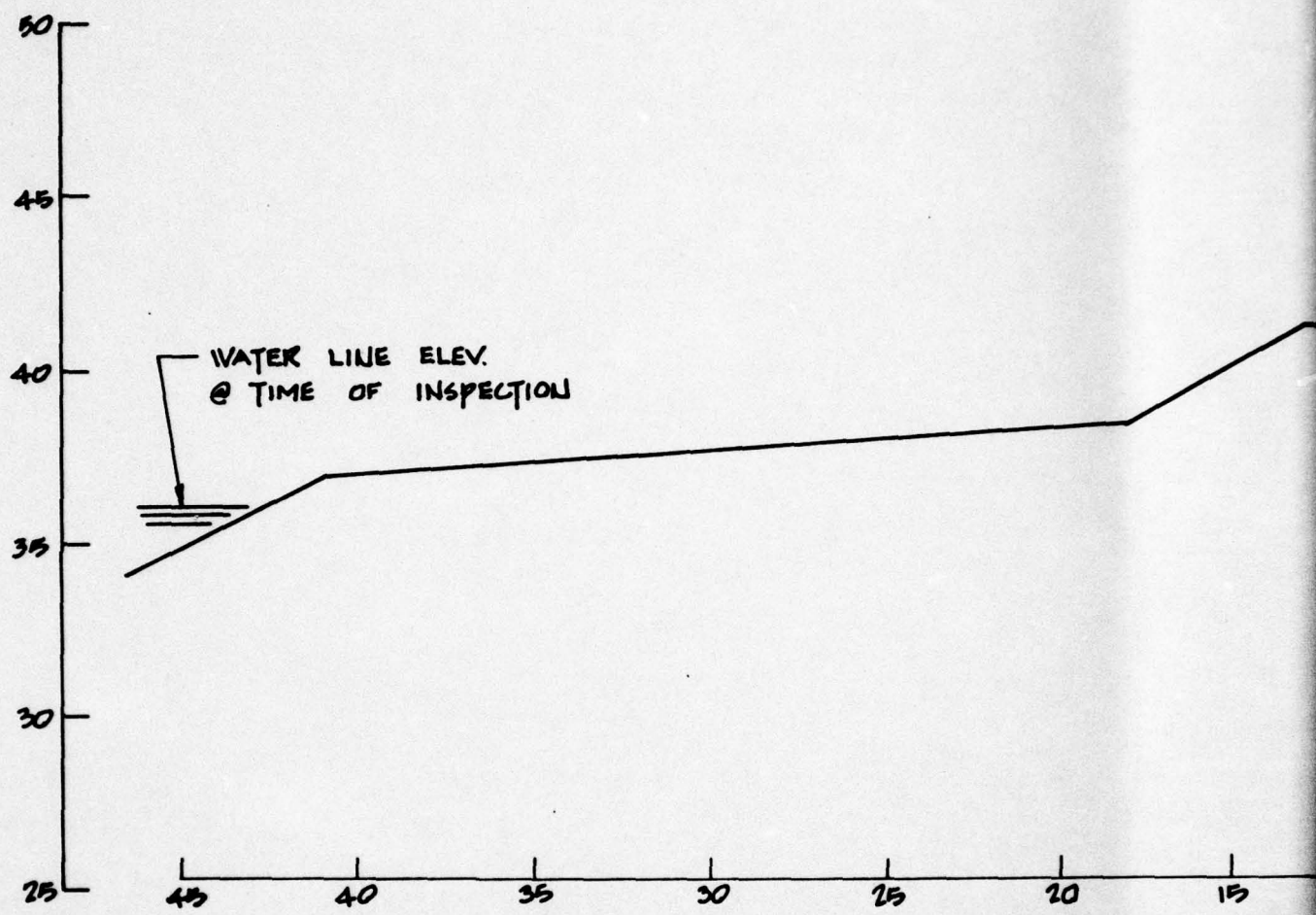


4 DAM PROFILE

SCALE: HORIZ. 1" = 30'
VERT. 1" = 10'

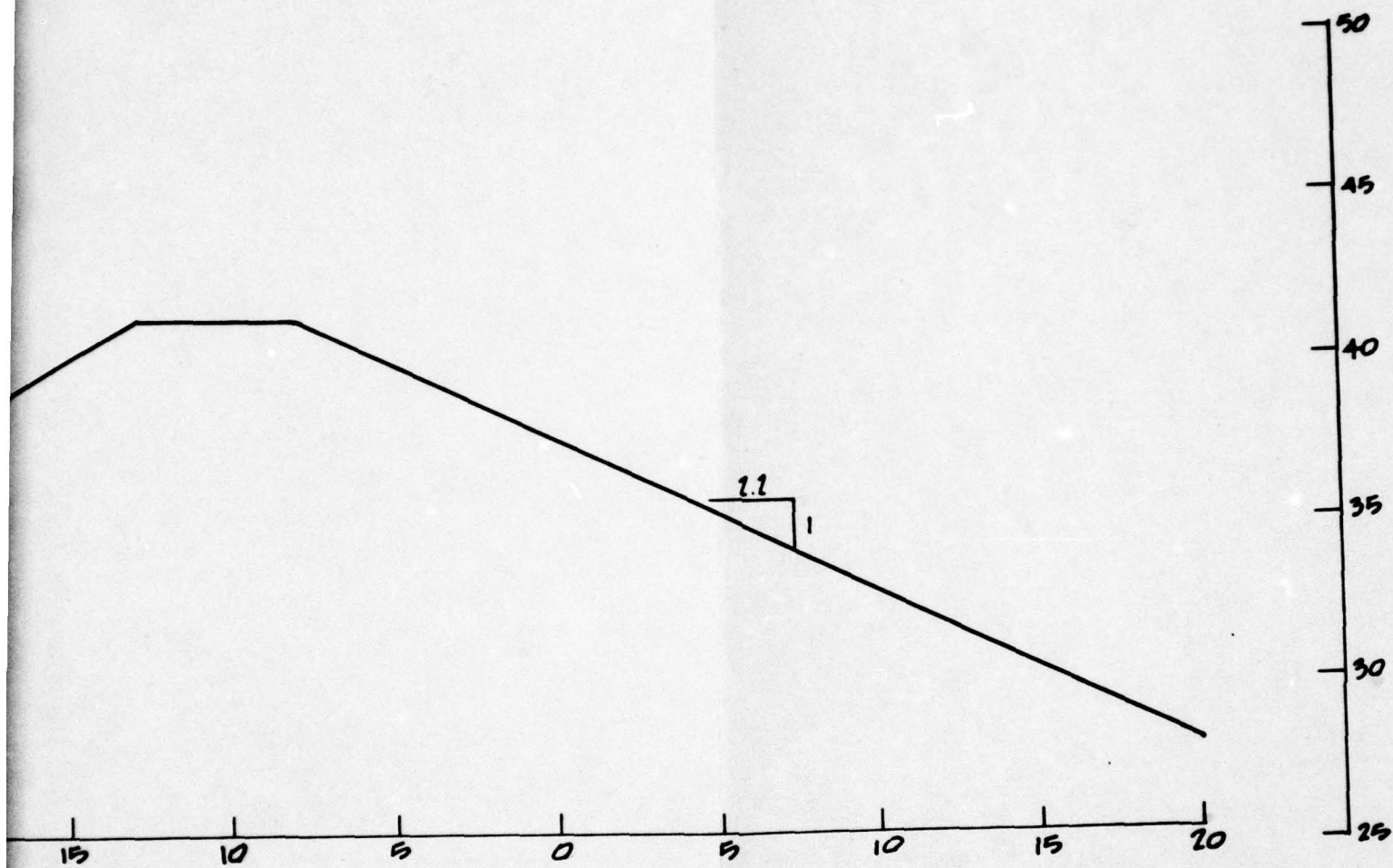
PLATE 5

2



CROSS-SECTION

SCALE: HORIZ.
VERT.

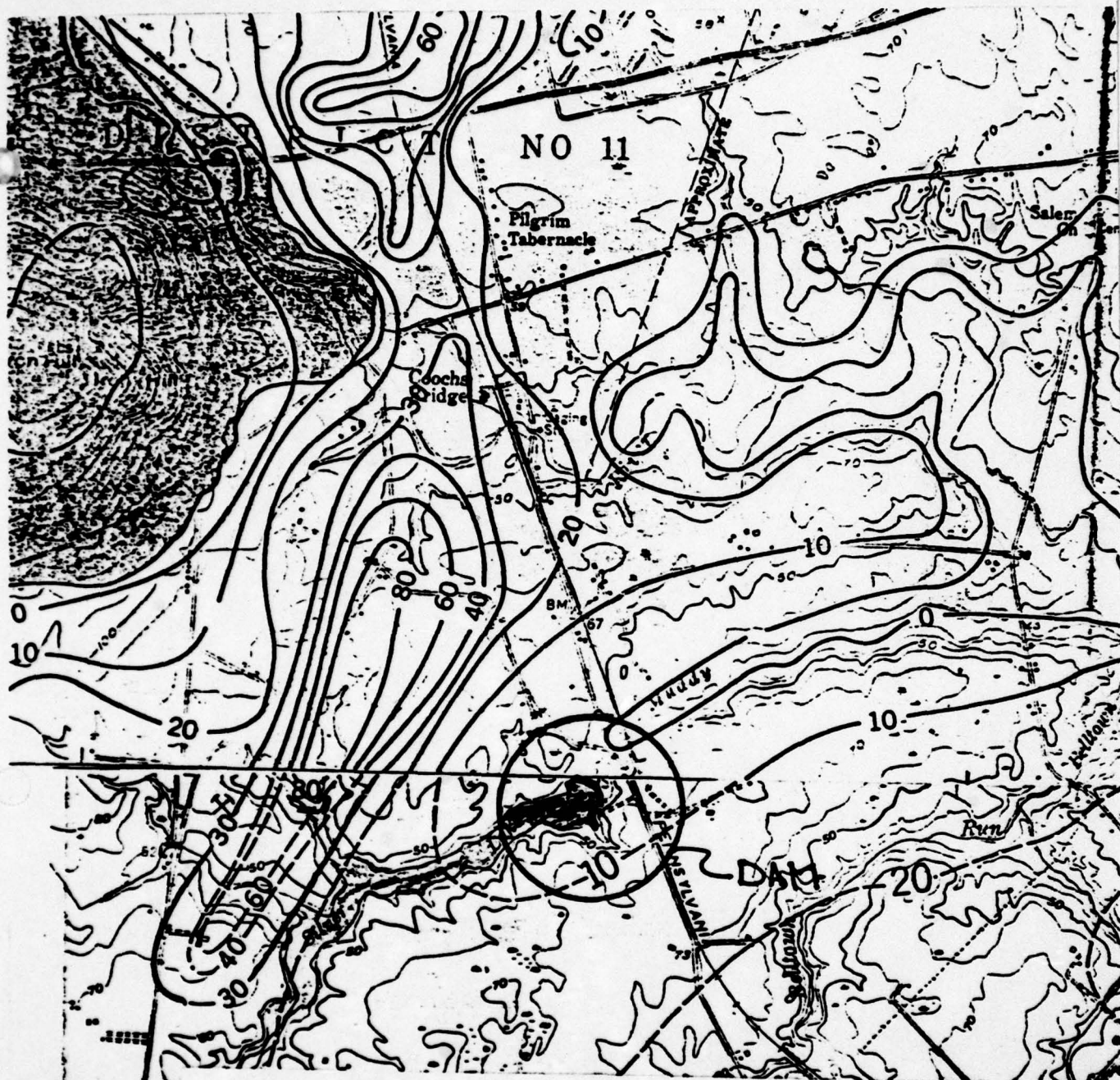


SECTION AT STA. 0+40

SCALE: HORIZ. 1" = 5'
VERT. 1" = 5'

PLATE 6

2



According to information obtained from the Delaware Geologic Survey, the dam is placed on the Columbia Formation (Fm) which is a fluvial pleistocene deposit about 5 feet or less in depth at this location. The Columbia overlies the Potomac formation (Kpt) which depth is estimated at 250 ft. consisting of variegated red, gray, purple, yellow and white lignitic silts and clays. The formation contains interbedded white gray and rust-brown quartz sands and some gravels.

GEOLOGIC MAP
PLATE 1

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

**CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA**

Check List
Visual Inspection
Phase 1

Name Dam Sunset Lake Dam County New Castle State Delaware Coordinates North 39°37'30"
West 75°43'30"

Date(s) Inspection Oct. 26, 1978 Weather Partly cloudy Temperature 70°

Pool Elevation at Time of Inspection 36.0 M.S.L. Tallwater at Time of Inspection 26.9 M.S.L.

Inspection Personnel:

Jerry Weintraub _____

Wayne Lippincott _____

*Krishna G. Patel _____

Jerry Weintraub Recorder

*Krishna G. Patel, Division Engineer
Delaware Dept. of Natural Resources & Environmental Control
Division of Soil and Water Conservation

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	<p>Concrete Gravity Overflow Structure exhibits repair patch-work throughout its length. Spalling of concrete noticeable on the downstream exposed face of the west wingwall and the downstream extreme ends of each wingwall. Much debris scattered on crest, each end of spillway. West wingwall height has been increased in past from appearance of concrete. Stone splash area in good condition.</p> <p>Stone/Earth-Fill Overflow Structure - the stone forming the splash area is deteriorating and only small amounts of mortar which originally bonded the stone together still exist. Erosion of the downstream bed is evident. The splash area stone is loose. The mortar bonding the stone wall together is deteriorating although the stone appears still intact.</p>	<p>Spalling areas should be sounded for additional deteriorated concrete. The defective areas should then be filled with non-shrink grout.</p> <p>The splash-area stone should be repaired to prevent further undermining of wall retaining earth fill.</p>
WATER PASSAGES	N/A	
FOUNDATION	N/A	
DRAINS	N/A	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SURFACE CRACKS CONCRETE SURFACES

Surface cracks appear in the west wingwall at the concrete overflow structure, at the location where the wall had been raised in height by adding a layer of concrete. At the junction between the layers, a crack had formed.

STRUCTURAL CRACKING

None Observed

VERTICAL AND HORIZONTAL ALIGNMENT

The top of the overflow structure varies in elevation. The concrete overflow structure is approximately 9 inches lower than the stone/earth-fill overflow. No horizontal distortions are noted.

MONOLITH JOINTS

None Observed

CONSTRUCTION JOINTS

None Observed

3.11.80

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None Observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None Observed	
SLoughING OR EROSION OF EMBANKMENT AND ADJUTENT SLOPES	None Observed	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	No horizontal distortions were noted. The embankment varies in elevation along its length.	
RIPRAP FAILURES	None Observed	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Erosion of the embankment adjacent to the west wingwall is noted.	Place stone rip-rap on the embankment to prevent further erosion.
ANY NOTICEABLE SEEPAGE	None Observed	
STAFF GAGE AND RECORDER	Does Not Exist	
INSTRUMENTS	None Observed	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	N/A	
OUTLET STRUCTURE	N/A	
OUTLET CHANNEL	N/A	
EMERGENCY GATE	18" diameter reinforced concrete pipe with valve for gate.	Does not appear capable to draw down lake in adequate time during an emergency.

UNCOATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	See Concrete/Masonry Dams	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	Water discharges onto a stone splashway at the overflow structure.	
BRIDGE AND PIERS	N/A	

GATED SPILLWAY

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

CONCRETE SILL

N/A

APPROACH CHANNEL

N/A

DISCHARGE CHANNEL

N/A

BRIDGE AND PIERS

N/A

GATES AND OPERATION
EQUIPMENT

N/A

RESERVOIR

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

SLOPES

Low sloping and well vegetated with trees and grass.

SEDIMENTATION

None Observed

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)

Some fallen trees and debris has collected immediately downstream of the overflow structure.

The downstream area should be cleaned up to prevent a possible build-up.

SLOPES

Low sloping and well vegetated. Some isolated areas exhibit signs of erosion.

APPROXIMATE NO. OF HOMES AND POPULATION

Approximately 100 trailer homes and 300 people just below railroad crossing.

The size of the culvert under the 35' high railroad embankment will restrict the flow of flood waters reaching the area of the trailer homes.

INSTRUMENTATION		REMARKS OR RECOMMENDATIONS
VISUAL EXAMINATION MONUMENTATION/SURVEYS	OBSERVATIONS	
	N/A	
OBSERVATION WELLS	N/A	
WEIRS	N/A	
PIEZOMETERS	N/A	
OTHER	N/A	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

REMARKS

ITEM

PLAN OF DAM None Available; Plan enclosed in this report based on our survey.

REGIONAL VICINITY MAP Available

CONSTRUCTION HISTORY No records to account for the construction history of the dam are available.

TYPICAL SECTIONS OF DAM None Available; Sections enclosed in this report based on our survey.

HYDROLOGIC/HYDRAULIC DATA None Available

OUTLETS - PLAN

- DETAILS

- CONSTRAINTS
 - DISTANCE RATINGS

None Available

NATIFALL/RESERVOIR RECORDS

ITEM	REMARKS
------	---------

DESIGN REPORTS	None Available
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GEOLOGY REPORTS	None Available
-----------------	----------------

DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None Available
---	----------------

MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None Available
---	----------------

POST-CONSTRUCTION SURVEYS OF DAM	None Available
----------------------------------	----------------

BORROW SOURCES. Owner stated that recent embankment modifications accomplished with on-site materials.

ITEM	REMARKS
------	---------

MONITORING SYSTEMS	None Exist
--------------------	------------

MODIFICATIONS	According to the owner, the older stone overflow structure was augmented by the addition of the concrete gravity overflow structure in 1941+. The embankment height and west wingwall height were increased approximately 1966.
---------------	---

HIGH POOL RECORDS	None Exist
-------------------	------------

POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	No formal reports exist
---	-------------------------

PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None on record
---	----------------

MAINTENANCE OPERATION RECORDS	No records available
-------------------------------	----------------------

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	None Available
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	None Available

APPENDIX B

PHOTOGRAPHS

PHOTOS TAKEN DURING OCTOBER, 1978

DETAILED PHOTOGRAPH DESCRIPTIONS

- Overall View of Dam - View of downstream face of Concrete Overflow Structure, October 26, 1978

- PHOTO 1 - View of overflow structure and adjoining embankments.
- PHOTO 2 - View overlooking west wing wall of concrete overflow structure and intersecting west embankment. Debris on the crest of structure and erosion of the embankment are notable on the photograph.
- PHOTO 3 - View looking toward west wing wall. A horizontal surface crack is notable where the wall height may have been increased.
- PHOTO 4 - View of spalled concrete at downstream end of west wing wall. Horizontal crack notable where two separate pours (layers) of concrete have not been joined correctly. Crack not apparent on stream face of wall.
- PHOTO 5 - View overlooking east wing wall of concrete overflow structure. Layers of concrete notable to apparently raise height of wall. Debris on structure also notable.
- PHOTO 6 - End view of east wing wall of concrete overflow structure. Dark grey mass of concrete apparently added to reinforce overflow structure on east end. Erosion at end of wall notable as well as trees and debris on wall.
- PHOTO 7 - View of downstream face of stone/earth-fill overflow structure. Deterioration of splashway stone is notable, also grassed area fronting wall.
- PHOTO 8 - View looking downstream from railroad embankment toward trailer Park.
- PHOTO 9 - Muddy Run looking downstream from Sunset Lake Dam.
- PHOTO 10 - Route 72 highway bridge looking downstream.
- PHOTO 11 - Detail of stone splashway of stone overflow dam.
- PHOTO 12 - View of water overflowing concrete dam.

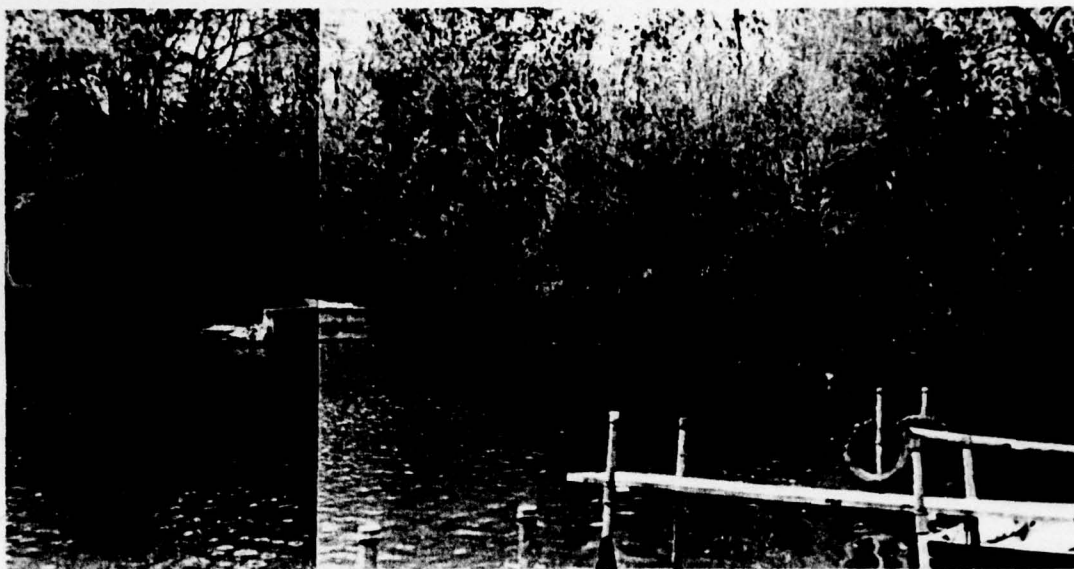


PHOTO 1



PHOTO 2

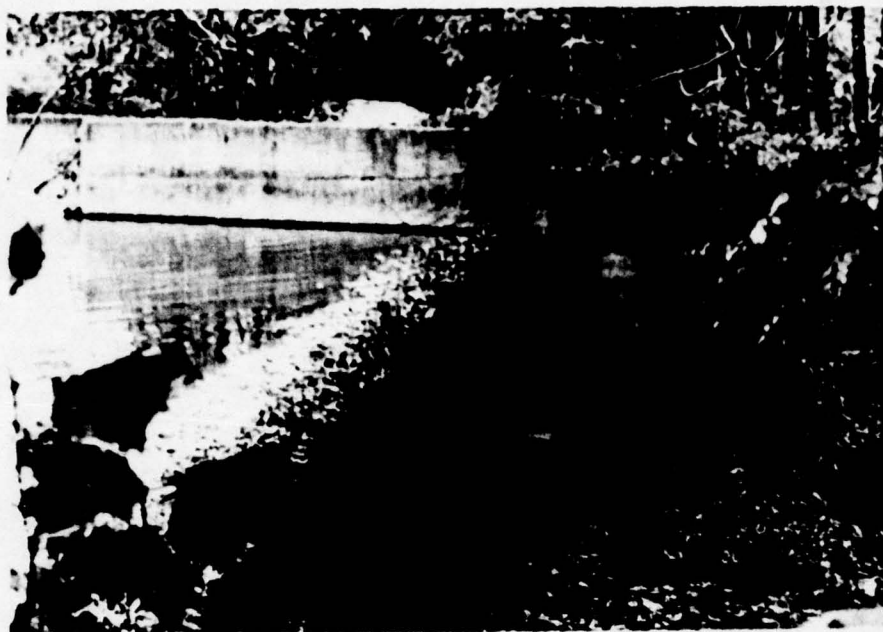


PHOTO 3



PHOTO 4



PHOTO 5



PHOTO 6



PHOTO 7



PHOTO 8



PHOTO 9

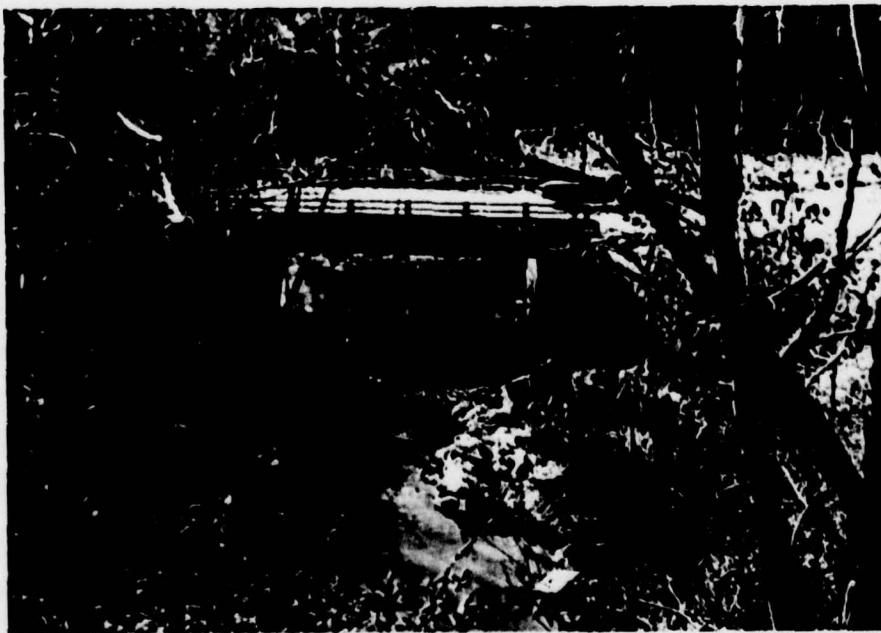


PHOTO 10



PHOTO 12



PHOTO 11

APPENDIX C

SUMMARY OF ENGINEERING DATA

**CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA**

DRAINAGE AREA CHARACTERISTICS: 8.2 square miles - Part in Coastal
Plain, Part in Piedmont Region

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 36.0 ft.(MSL) (147 Ac.Ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: 41.5 ft. (MSL) (554 Acre Ft.)

ELEVATION TOP DAM: 39.9 ft. (MSL) Minimum

CREST: _____

- a. Elevation 36.0 ft.+ at Concrete Overflow and 36.75 ft. at stone/earth-fill
- b. Type Concrete Gravity & Stone/Earth-fill Overflow
- c. Width Concrete: 2.3 ft., Stone: 4.0 ft.
- d. Length 110 ft. (overall)
- e. Location Spillover Most frequent at Concrete Overflow
- f. Number and Type of Gates N/A

OUTLET WORKS: _____

- a. Type 18" Diameter concrete pipe with gate valve
- b. Location East end of embankment
- c. Entrance inverts -
- d. Exit inverts 27.88 ft. (MSL)
- e. Emergency draindown facilities Gate valve is operable

HYDROMETEOROLOGICAL GAGES: None

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: Unknown

APPENDIX D

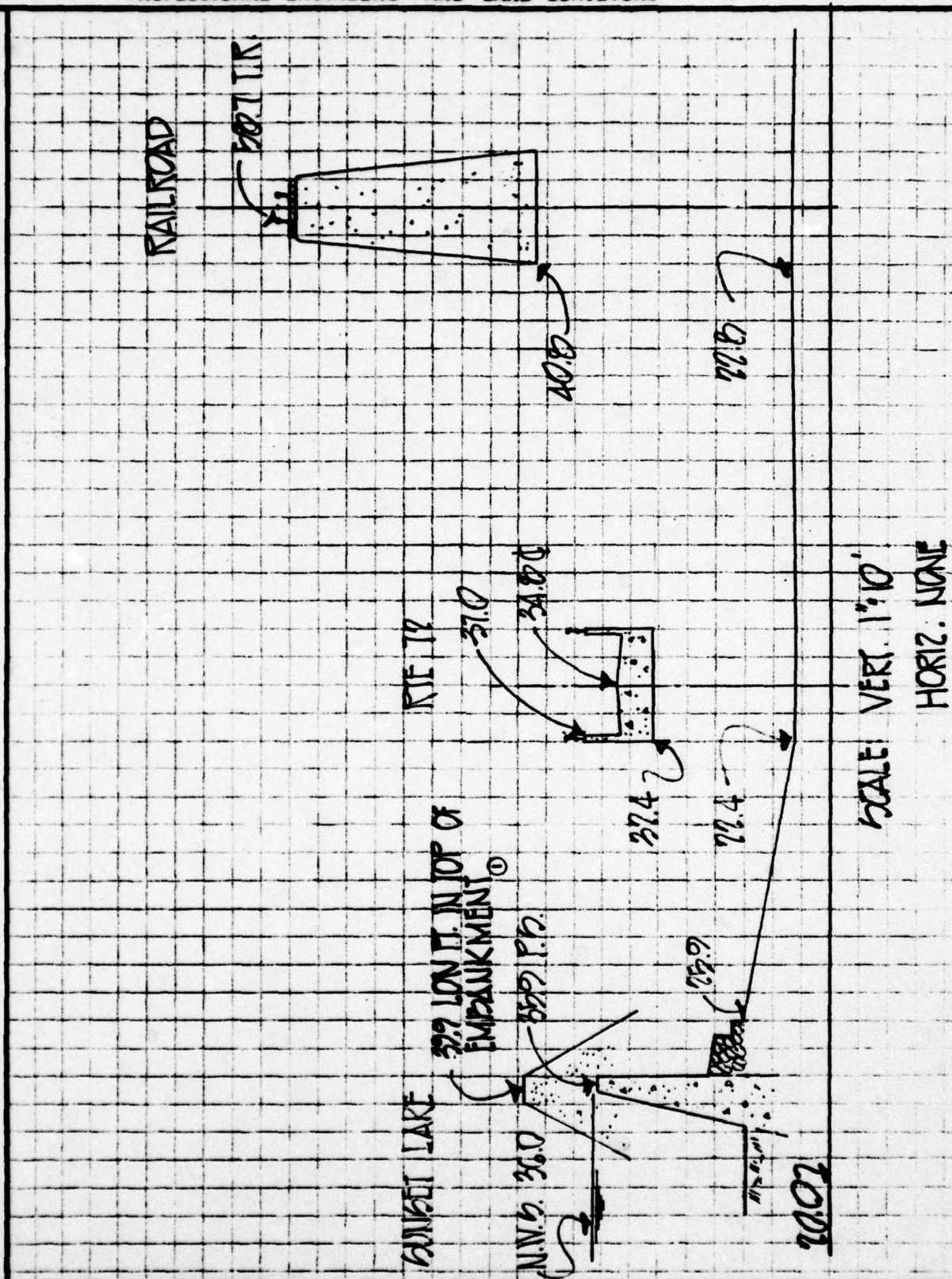
HYDROLOGIC COMPUTATIONS



WATERSHED MAP

SUNSET LAKE DAM

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS



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-01-201

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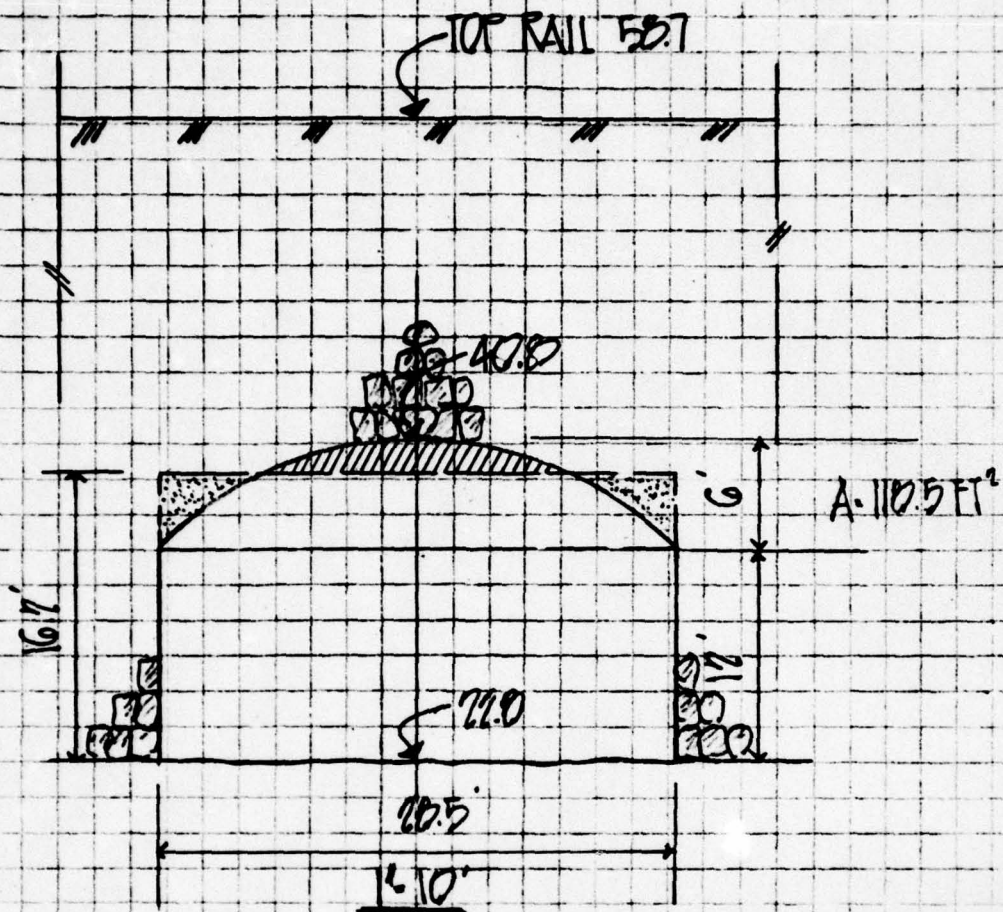
Checked By

12/21/79
Date
① REV. 11/1/79
Date

Calculations For: SUNSET LAKE DAM

Sheet 1
Of

THOMAS TYLER MOORE ASSOCIATES, INC.
 PROFESSIONAL ENGINEERS AND LAND SURVEYORS



EQUIV. H = $110.5 / 20.5 \cdot 4.2'$

FOR ANALYSIS: CONSIDER R.R. BRIDGE AS A 20.5' x 16.2'

BOX CULVERT FLOWING UNDER INLET
 CONTROL. ENTRANCE CONDITION (?)

N

Calculated By

Date

Calculations For:
 R.R. BRIDGE

Sheet

2

Checked By

Date

Of

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

HV/D (ASSUME)	RATIO Q/B (READ)	Q. RATIO x B (CALC. IN CFS)	HV = HV/D x 16.2 (CALC. IN FT.)	ELEV. INN. 22.8
0.35	35	940	5.1	28.5
0.37	37	1,054	6.0	28.8
0.40	55	1,568	8.0	30.8
0.62	78	2,223	10.0	32.8
0.74	105	2,991	12.0	34.8
0.86	130	3,105	14.0	36.8
0.99	165	4,102	16.0	38.8
1.11	190	5,415	18.0	40.8
1.23	220	6,270	20.0	42.8
1.36	250	7,125	22.0	44.8
1.48	270	7,695	24.0	46.8
1.60	295	8,400	26.0	48.8
1.73	315	8,978	28.0	50.8
1.85	335	9,548	30.0	52.8
1.98	350	9,975	32.0	54.8
2.1	370	10,545	34.0	56.8
2.2	390	11,115	36.0	58.8

cf N2

Calculated By

Date

Calculations For

INLET CONTROL
R.R. BRIDGE

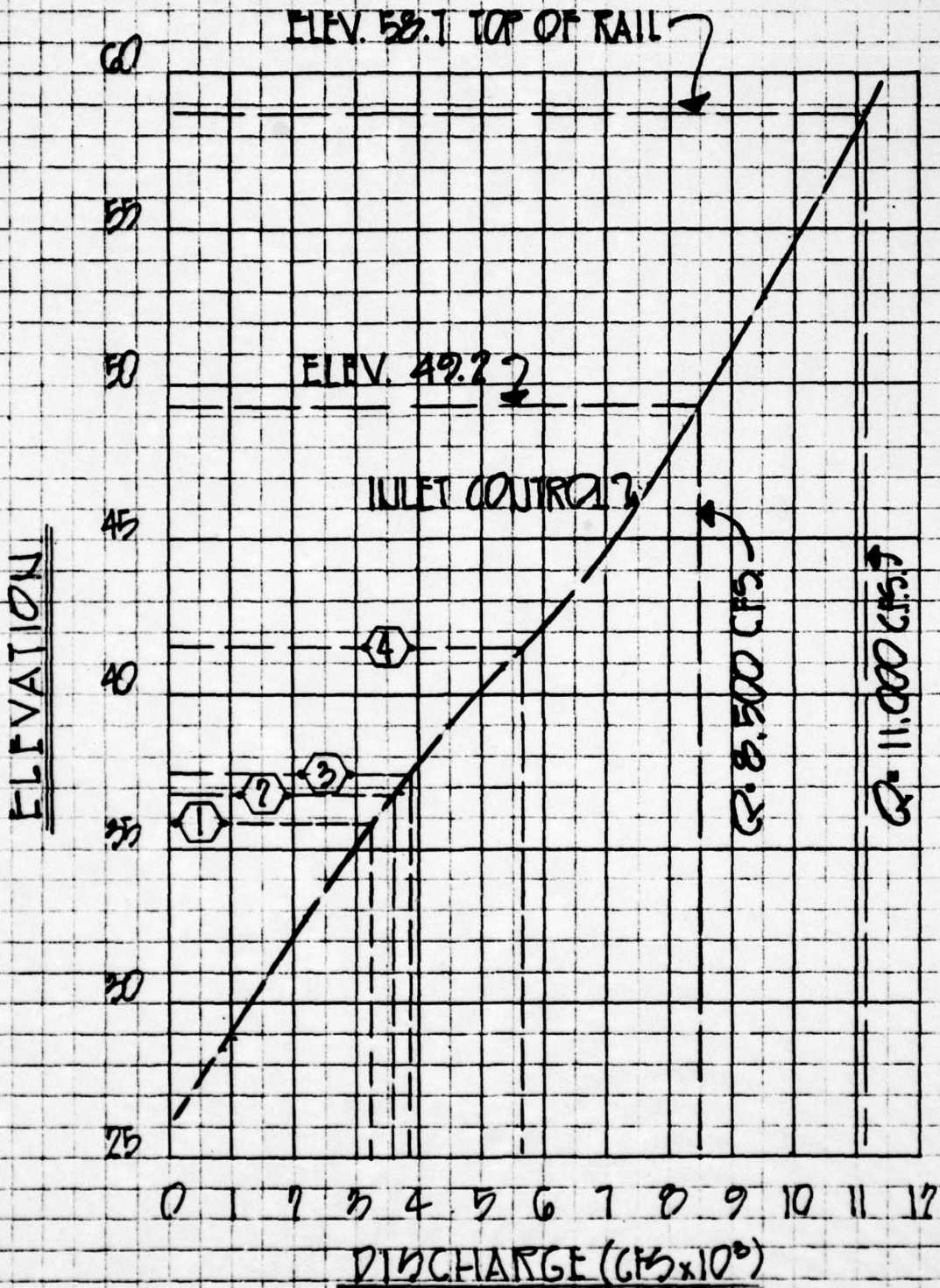
Sheet

3

of

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

① EL. 33.9, Q. 2,200 CFS. ② EL. 36.0, Q. 3,600 CFS. ③ EL. 37.4, Q. 3,800 CFS. ④ EL. 41.5, Q. 5,100 CFS.



CI N2

Calculated By

Date

Calculations For:

STAGE-DISCHARGE

R.R. BRIDGE

Sheet

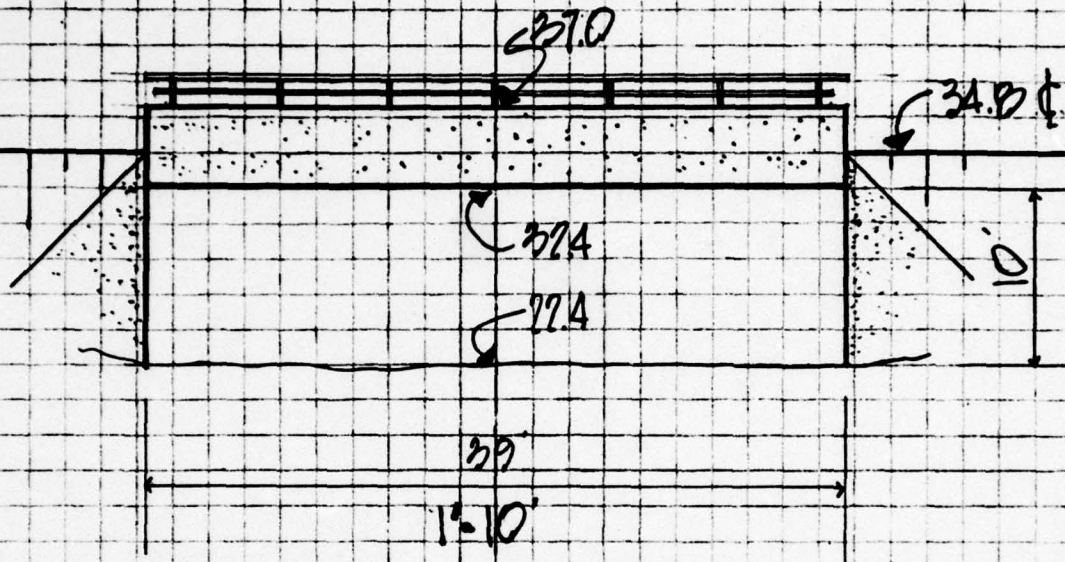
4

Of

Checked By

Date

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS



FOR ANALYSIS: CONSIDER HWY. BRIDGE AS A 39'x10'
BOX CULVERT:

FOR INLET CONTROL USE ENTRANCE
CONDITION 1

FOR OUTLET CONTROL USE T.V. RELATED
TO H.W. ON DOWNSTREAM N.R. BRIDGE.

$K_e = 0.4$, $L = 60'$, $S_o = 0$

Calculated By

Date

Calculations For:

ROUTE 12 BRIDGE

Sheet

5

Of

Checked By

Date

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

HV/D APPROX	RATIO Q/D (READ)	Q-RATIO x D (CALC. IN CFS)	H.V. - HV/D x 10 (CALC. IN FT.)	ELEV. IN. 224
0.20	155	604	2.0	25.4
0.40	24	936	4.0	26.4
0.50	34	1386	5.0	27.4
0.60	45	1755	6.0	28.4
0.70	56	2184	7.0	29.4
0.80	68	2652	8.0	30.4
0.90	80	3120	9.0	31.4
1.00	92	3588	10.0	32.4
1.10	105	4095	11.0	33.4
1.20	115	4485	12.0	34.4

TOP OF RDWY EL 34.8

NOTE: WEIR FLOW OVER RDWY HAS NOT BEEN ANALYZED

1	Calculated By <u>CAK</u>	Date <u>RD. 2/8/79</u>	Calculations For: <u>INLET CONTROL</u> <u>RTE 72 BRIDGE</u>	Sheet <u>6</u>
	Checked By _____	Date _____		Of _____

DATA FOR OUTLET CONTROL (32x10 BOX CULVERT)

$$K_e = 0.4, n = 0.015, L = 60' \pm$$

$$A = 32 \times 10 = 320 \text{ FT}^2$$

$$N.P. = (10 \times 7) + (32 \times 7) = 98 \text{ FT} \quad \left. \vphantom{\begin{matrix} A \\ N.P. \end{matrix}} \right\} \text{ FLOWING FULL}$$

$$R = A/N.P. = 3.26$$

$$H = \left[1 + K_e + \frac{29 n^2 L}{R^{1.33}} \right] V^2 / 2g$$

$$H = \left[1 + 0.4 + \frac{29 \times (0.015)^2 \times 60}{(3.26)^{1.33}} \right] V^2 / 64.4$$

$$H = 0.0227 V^2$$

$$V = Q/A = Q/320$$

1 N-

Calculated By

Date

Checked By

Date

Calculations For:

OUTLET CONTROL
RT 72 BRIDGE

Sheet

7

Of

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

Q (C.F.S.) (ASSUME)	V (FT/SEC)	H (FT.)	T.W (FT)	H.W. H+T.W	ELEV. INV. 22.4
604	1.55	0.05	5.4	5.4	27.8
956	2.40	0.13	6.1	6.2	28.6
1326	3.40	0.3	7.0	7.1	28.5
1755	4.50	0.5	9.1	9.6	32.0
2184	5.60	0.7	10.0	10.7	33.1
2652	6.80	1.0	11.5	12.5	34.9
<u>TOP OF RDWY. EL 34.8</u>					

NOTE: WEIR FLOW OVER RDWY. HAS NOT BEEN ANALYZED

CAR
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REV. 3/2/79
Date

Calculations For:
COLLET CENTRA

Sheet 2

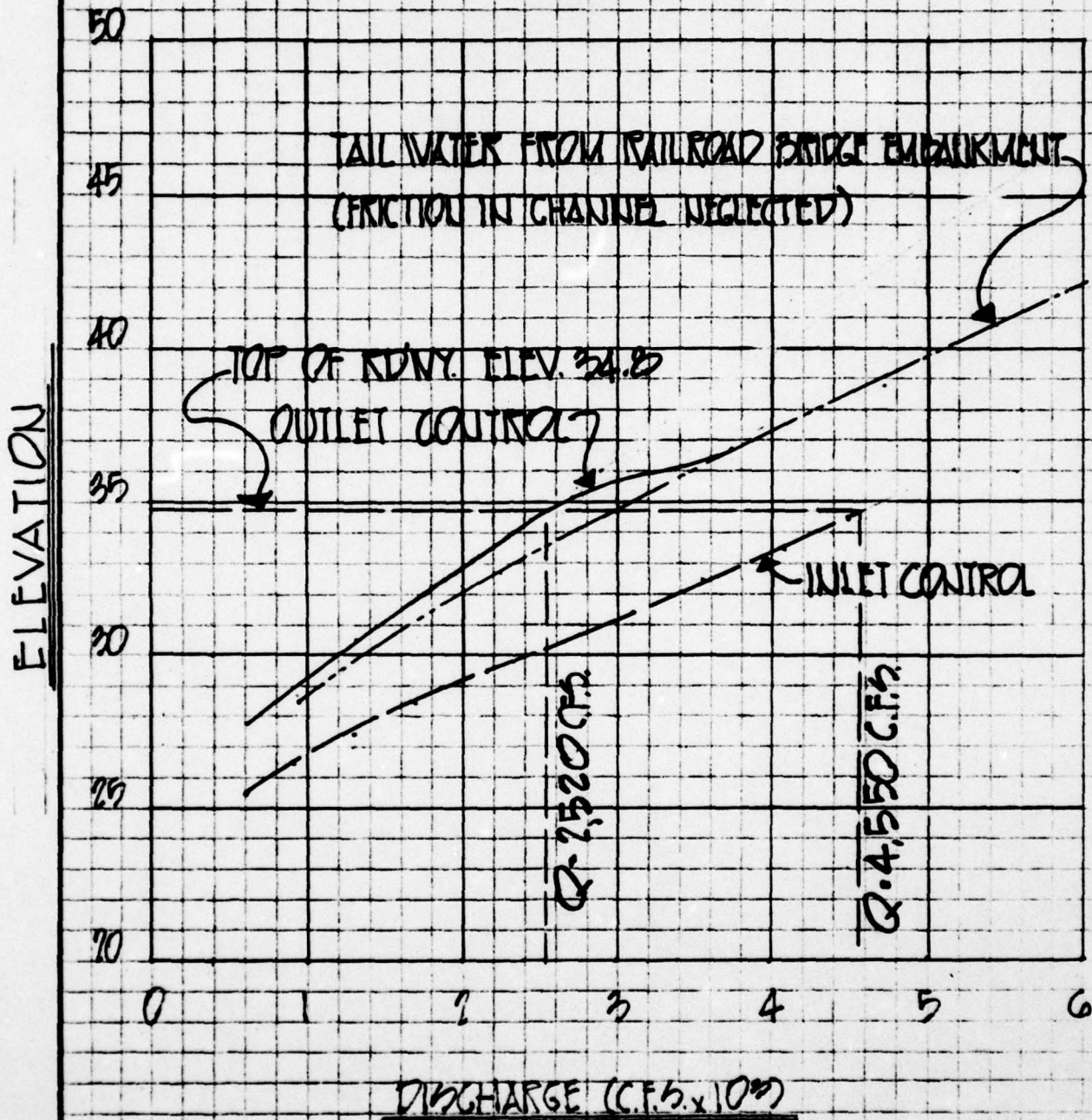
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Date

Of

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

ASSUMED TAILWATER FROM RAILROAD EMBANKMENT
CONTROLS ABOVE WATER SURFACE ELEV. 34.5



1 2

CAR
Calculated By
Checked By

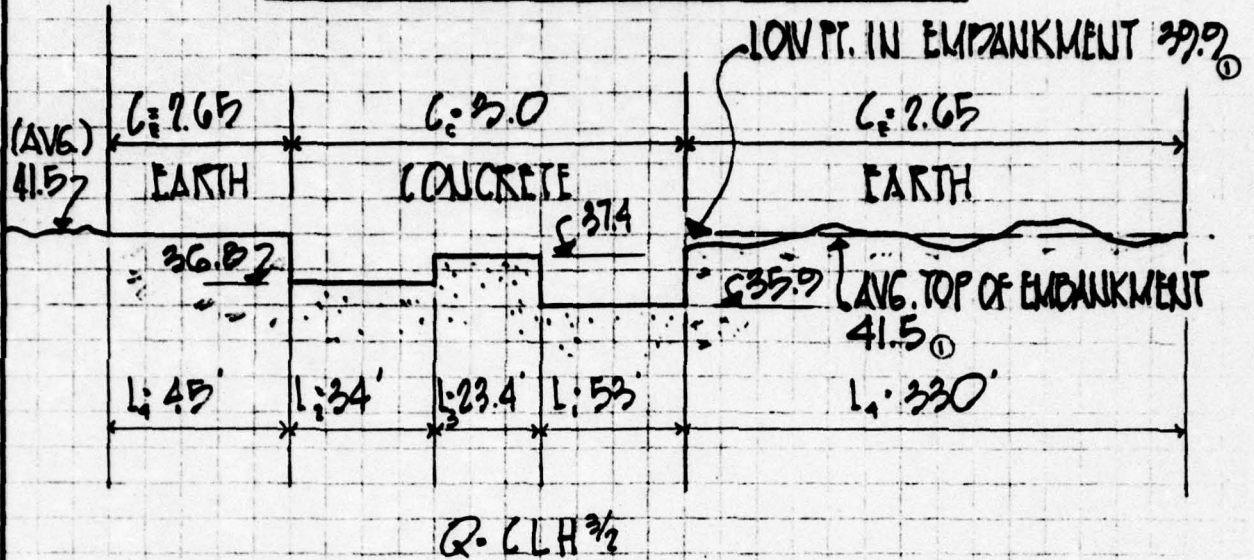
2/2/79
Date
Date

Calculations For:
BRIDGE - DISCHARGE
RTE. 72 BRIDGE

Sheet 9
Of

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

"SECTION USED FOR ANALYSIS"



Calculated By _____
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① Rev. 3/1/79
Date _____

Calculations For:
SUNSET LAKE DAM

Sheet 10
Of _____

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

COMMENTS									
EFFECT OF VEIR BY TAILWATER FROM RT. 72 LOAD BRIDGE/EMBANKMENT VEIR COEFFICIENT FIG TO FIG. 24 IN "HYDRAULICS OF BRIDGE U.S. D.O.T., F.H.A. PUBLISHED 1973.									
FOR PURPOSES AN AVERAGE TOP OF EV. OF 41.5 WAS USED ⁽²⁾									
EL.	H ₁	H ₂	H ₃	H ₄	T.M.	D/H ₁	D/H ₂	D/H ₃	D/H ₄
35.9	0								
36.0	0.9	0							
37.4	1.5	0.6	0						
38.0	2.1	1.2	0.6						
39.0	3.1	2.2	1.6						
40.0	4.1	3.2	2.6						
41.0	5.1	4.2	3.6		35.9				
41.5	5.6	4.7	4.1	0	37.0	0.04			
42.0	6.1	5.2	4.6	0.5	38.7	0.16	0.37	0.25	
42.5	6.6	5.7	5.1	1.0	41.9	0.91	0.89	0.80	0.60
43.0	7.1	6.2	5.6	1.5	42.65	0.95	0.94	0.94	0.77
43.5	7.6	6.7	6.1	2.0	43.3	0.97	0.97	0.97	0.90
44.0	8.1	7.2	6.6	2.5	43.81	0.98	0.98	0.98	0.95

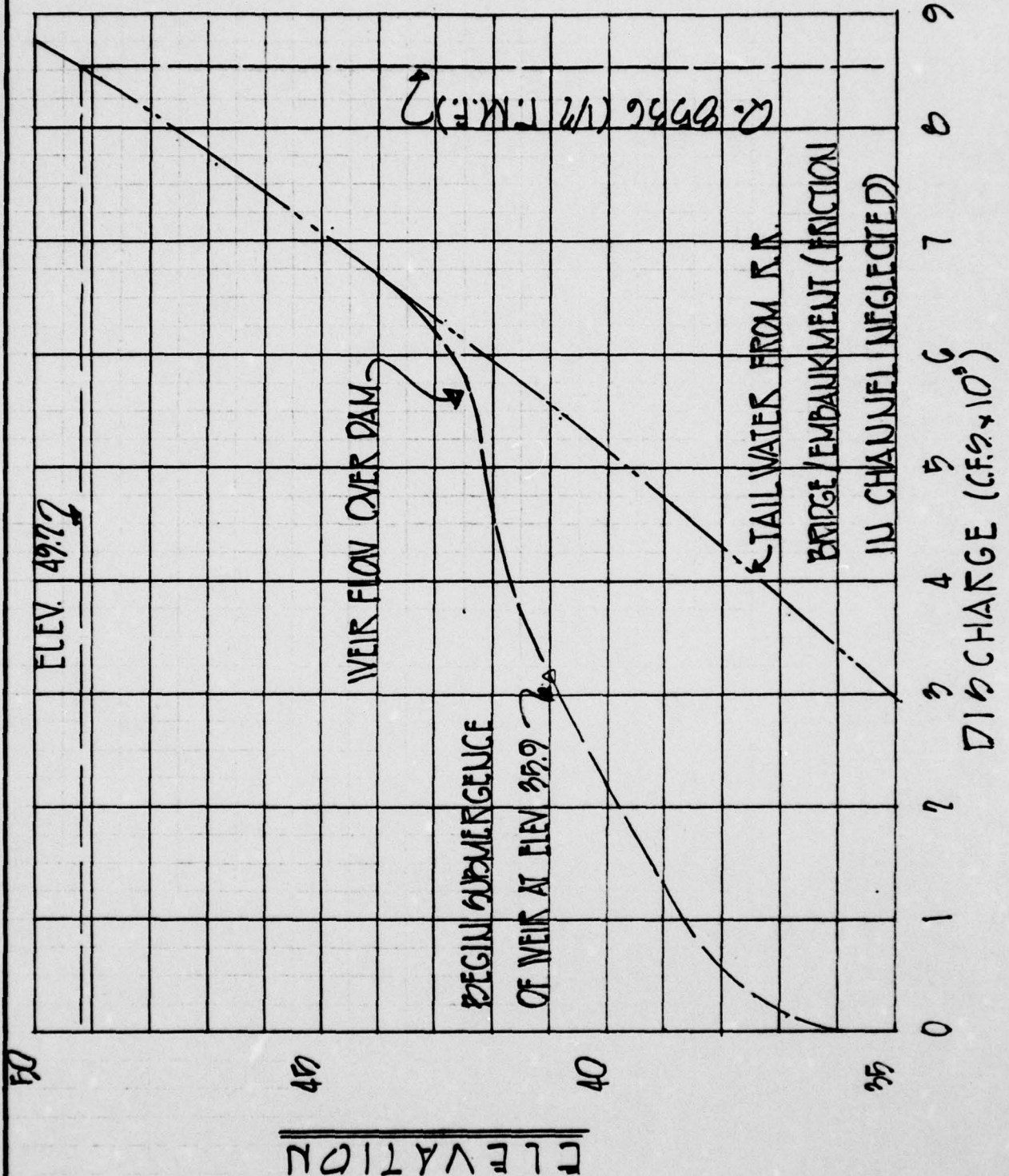
CAR
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Checked By _____

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REV. 2/2/79
Date _____

Calculations For:
STAGE - DISCHARGE
SUNSET LAKE

Sheet 11
Of 11

THOMAS TYLER MOORE ASSOCIATES, INC.
 PROFESSIONAL ENGINEERS AND LAND SURVEYORS



N

Calculated By CAR
 Checked By _____

Date 8/2/79
 Date _____

Calculations For:
STAGE-DISCHARGE
SUNSET LAKE

Sheet 12
 Of _____

EL.	H ₁	H ₂	H ₃	H ₄	T.M.	D/H ₁	D/H ₂	D/H ₃	D/H ₄	C _c	C _E	G ₁ /C _F	G ₂ /C _F	G ₃ /C _F	G ₄ /C _F	L ₁	L ₂	L ₃
35.9	0									3.0						5.3		
36.8	0.9	0															34	
37.4	1.5	0.6	0															23.4
38.0	2.1	1.2	0.6															
39.0	3.1	2.2	1.6															
40.0	4.1	3.2	2.6															
41.0	5.1	4.2	3.6		35.9													
41.5	5.6	4.7	4.1	0	37.0	0.20	0.04				2.65	1.0	1.0	1.0				
42.0	6.1	5.2	4.6	0.5	38.1	0.46	0.31	0.25				1.0	1.0	1.0				
42.5	6.6	5.7	5.1	1.0	41.9	0.91	0.89	0.88	0.60			0.91	0.99	0.96	1.0			
43.0	7.1	6.2	5.6	1.5	42.65	0.95	0.94	0.94	0.77			0.78	0.88	0.88	1.0			
43.5	7.6	6.7	6.1	2.0	43.3	0.97	0.97	0.97	0.90			0.65	0.65	0.65	0.93			
44.0	8.1	7.2	6.6	2.5	43.81	0.98	0.98	0.98	0.95	↓	↓	0.55	0.55	0.55	0.78	↓	↓	↓

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REV. 2/2/79
Date

Checked By

Date

Calculations For:
STAGE - DISCHARGE

SUNSET LAKE

Sheet 11

01

L_2	L_3	L_4	$H_1\%$	$H_2\%$	$H_3\%$	$H_4\%$	Q_1	Q_2	Q_3	Q_4	ΣQ	COMMENTS
			0				0				0	FOR SUBMERGENCE OF WEIR BY TAILWATER
34			0.85	0			135	0			135	BRIDGE AND RAILROAD BRIDGE/EMBANKMENT
	23.4		1.84	0.46	0		292	47	0		339	REDUCED ACCORDING TO FIG. 24 IN "HYDRAULIC
			3.04	1.31	0.46		483	134	32		649	WATERWAYS" BY U.S. D.O.T., F.H.A. FOR
			5.46	3.26	2.07		868	332	142		1342	
			8.90	5.72	4.19		1320	583	294		2197	
			11.52	8.61	6.83		1832	878	479		3189	
		375	13.25	10.19	8.30	0	2107	1039	583	0	3729	FOR COMPUTATION PURPOSES AN AN
			15.07	11.86	9.87	0.35	2396	1210	693	348	4647	EMBANKMENT ELEV. OF 41.5 WAS USED
			16.96	13.61	11.52	1.00	2727	1319	777	994	5817	
			18.92	15.44	13.25	1.84	3246	1592	762	1828	6228	
			20.95	17.34	15.07	2.83	3865	1950	888	2615	6618	
			23.05	19.32	16.96	3.95	4516	2284	1055	3062	6817	

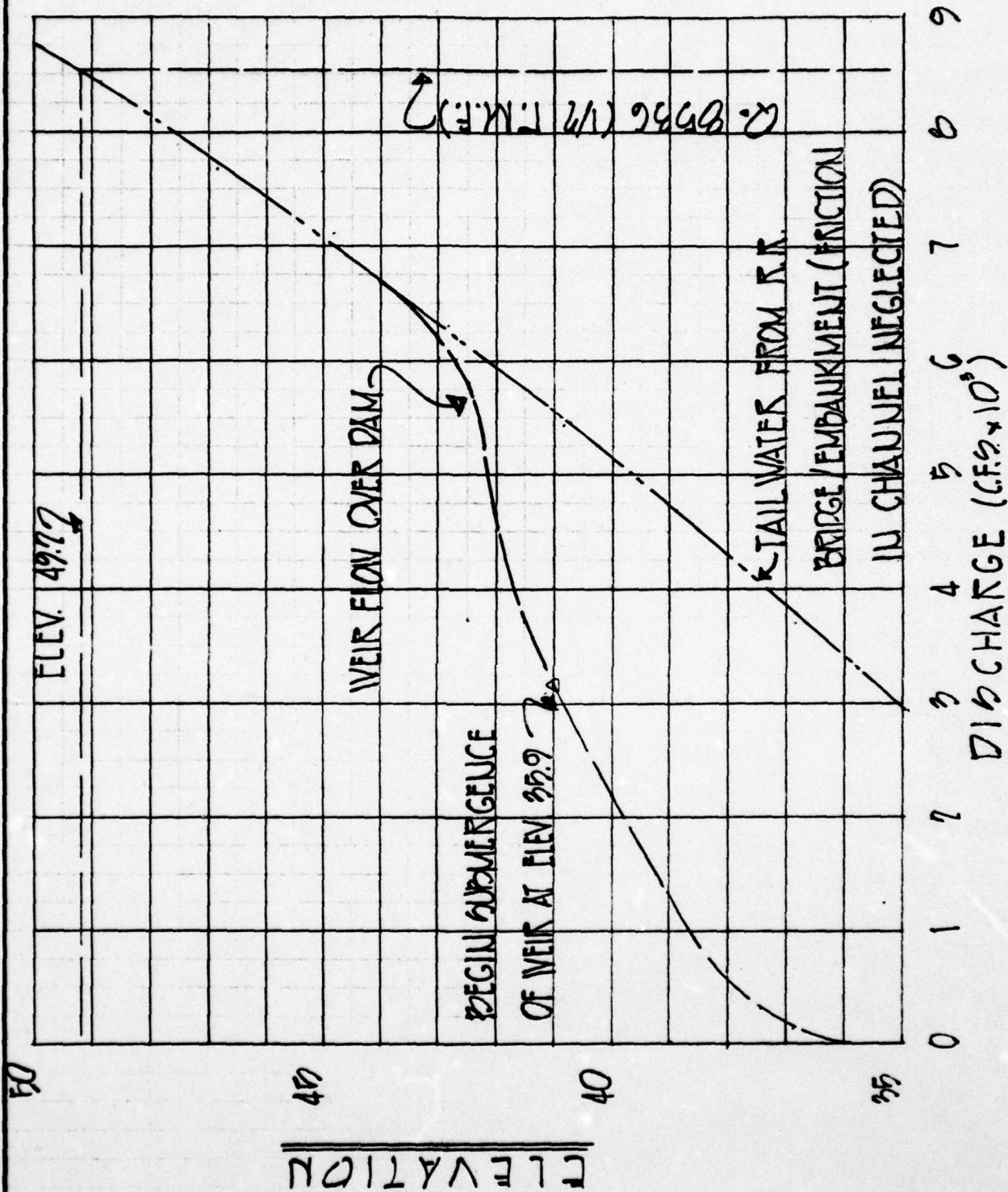
COMMENTS

EMERGENCE OF WEIR BY TAILWATER FROM RTE. 72
AND RAILROAD BRIDGE/EMBANKMENT WEIR COEFFICIENT
ACCORDING TO FIG. 24 IN "HYDRAULICS OF BRIDGE
WEIRS" BY U.S. D.O.T., F.H.A. PUBLISHED 1973.

COMPUTATION PURPOSES AN AVERAGE TOP OF
EMBANKMENT ELEV. OF 41.5 WAS USED⁽²⁾

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

THOMAS TYLER MOORE ASSOCIATES, INC.
 PROFESSIONAL ENGINEERS AND LAND SURVEYORS



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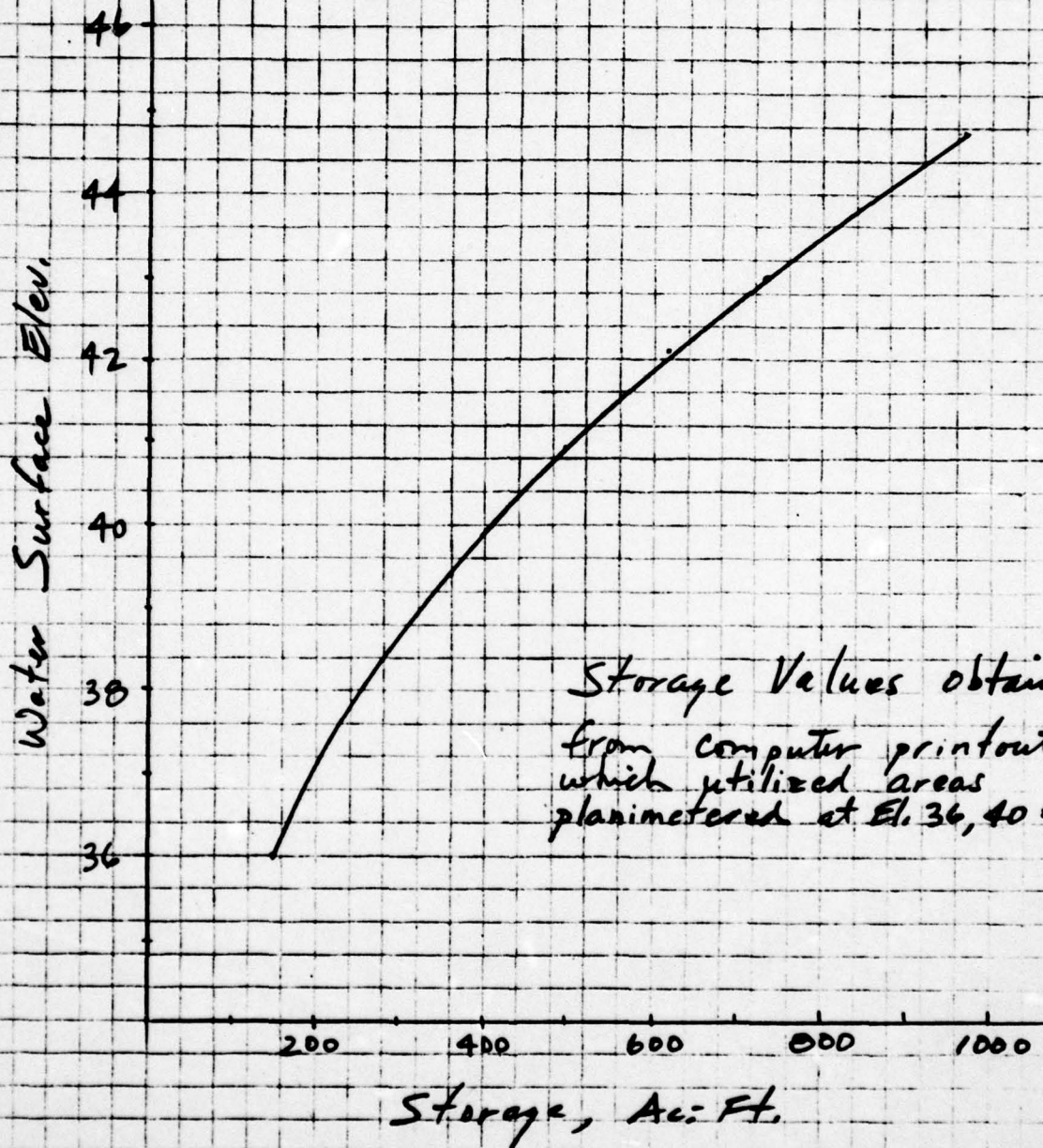
Calculated By CAR
 Checked By _____

Date REV 8/2/79
 Date _____

Calculations For:
STAGE-DISCHARGE
SUNSET LAKE

Sheet 17
 Of 11

THOMAS TYLER MOORE ASSOCIATES, INC.
 PROFESSIONAL ENGINEERS AND LAND SURVEYORS



Calculated By _____ Checked By _____	Date _____ Date _____	Calculations For: <u>Storage Curve - Sunset Lake</u>	Sheet <u>13</u> Of _____

THOMAS TYLER MOORE ASSOCIATES, INC.
PROFESSIONAL ENGINEERS AND LAND SURVEYORS

Calculate T_p :

$$T_p = C_t (L + L_{ca})^{0.3}$$
$$= 1.6 (5.11 + 2.84)^{0.3}$$

$$T_p = 3.6 \text{ Hr.}$$

N	Calculated By	Date	Calculations For: <u>T_p - Sunset Lake</u>	Sheet <u>14</u>
	Checked By	Date		Of <u> </u>

AD-A069 602

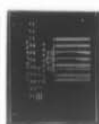
NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. SUNSET LAKE DAM (DE-00046). CHRIST--ETC(U)
FEB 79 T T MOORE

UNCLASSIFIED

DACW61-78-C-0124

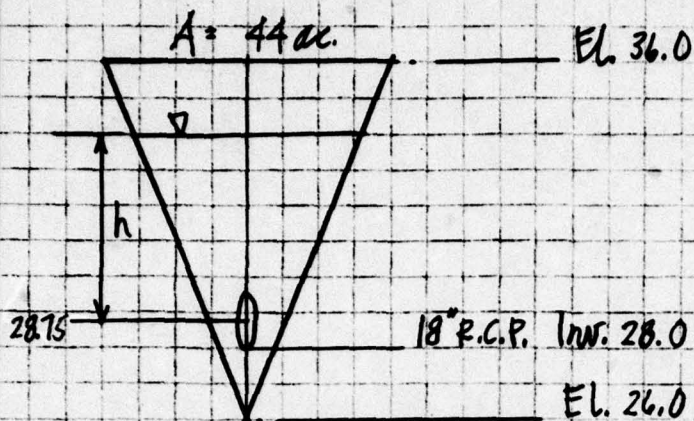
NL

2 OF 2
AD
A069602



END
DATE
FILMED

7-79
DDC



$$A = 44 \cdot 43560 \left(\frac{h+2.75}{10} \right)^2 = 19166(h+2.75)^2$$

$$Q = C_d \sqrt{2gh} = .6 \cdot \frac{\pi (1.5)^2}{4} \cdot \sqrt{2g} h^{\frac{1}{2}} = 8.51 h^{\frac{1}{2}}$$

$$Q dt = -A dh$$

$$8.51 h^{\frac{1}{2}} dt = -19166 (h+2.75)^2 dh$$

t in sec.

$$dt = -.6257 (h^{\frac{3}{2}} + 5.5 h^{\frac{1}{2}} + 7.56 h^{-\frac{1}{2}}) dh$$

t in hrs.

$$t = -.6257 \left(.4 h^{\frac{5}{2}} + 3.67 h^{\frac{3}{2}} + 15.12 h^{\frac{1}{2}} \right) \Big|_{7.25}^{15.75}$$

$$t = -.6257 (15.67 - 168.97) = 95.91 \text{ hrs.}$$

N₂

P.A.K.
Calculated By

Date

Calculations For
Sunset Lake Dam
drawdown

Sheet 15

Checked By

Date

Of

REVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

1
2

NUMBER HYDROGRAPH AT
ROUTE HYDROGRAPH TO
END OF NETWORK

03.11.91 03.11
012021/61 03100 0074

SUBJECT LAWYER
WAS IN THE INSPECTION -- STATE OF DELAWARE
RELATES TO REMEDY, THOMAS PYLE WONG ASSOCIATES

[illegible]

MULTI-PLAN ANALYSES TO BE PERFORMED
WPLANE 1 ACTION 1 ACTION 1

1000-1000

SUB-AREA RUNOFF COMPUTATION

DATE	TIME	TO	SUNSET	LAKE	ITAVE	JPLT	JPH-T	INAME	ISTAGE	IAUTO
1974	07:15	0	0	0	0	0	0	1	0	0

[illegible][illegible]

UNIT MIDWINTER DATA
175 3.60 LPS .05 N/A= 0

```

APPROXIMATE C-AN CURE RATINGS FROM GIVEN SURVEY CM      RTIO= 1.00
MEASUREMENT DATA      CHCS= 0.00      TPC= 0.00 AND 0.12 INTERVALS

```


UNIT INFORMATION AT END OF PERIOD UNITS: LBS										3.50 HOURS, CPM			.05 VOL. 1.00			764.		
										957.			957.			957.		
										200.			200.			200.		
										40.			40.			40.		
										4.			4.			4.		
										11.			11.			11.		
										11.			11.			11.		
										11.			11.			11.		
										11.			11.			11.		
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										11.			11.			11.		
										11.			11.			11.		

1.04	17.30	33	16.50	3761.	554.	41.9
1.04	17.30	34	17.00	3630.	546.	41.4
1.04	17.30	35	17.30	3661.	528.	41.3
1.04	17.30	36	17.30	3211.	504.	41.0
1.04	17.30	37	18.00	2949.	478.	40.8
1.04	17.30	38	18.00	2670.	452.	40.5
1.04	17.30	39	18.30	2400.	428.	40.2
1.04	17.30	40	18.30	2134.	403.	39.9
1.04	17.30	41	18.30	1852.	383.	39.7
1.04	17.30	42	18.30	1621.	367.	39.6
1.04	17.30	43	18.30	1424.	354.	39.4
1.04	17.30	44	18.30	1294.	342.	39.2
1.04	17.30	45	18.30	1115.	330.	39.1
1.04	17.30	46	18.30	907.	317.	38.9
1.04	17.30	47	18.30	723.	304.	38.7
1.04	17.30	48	18.30	640.	291.	38.5
1.04	17.30	49	18.30	577.	280.	38.4
1.04	17.30	50	18.30	517.	269.	38.2
1.04	17.30	51	18.30	462.	259.	38.1
1.04	17.30	52	18.30	410.	250.	37.9
1.04	17.30	53	18.30	361.	242.	37.8
1.04	17.30	54	18.30	315.	235.	37.7
1.04	17.30	55	18.30	272.	228.	37.6
1.04	17.30	56	18.30	231.	222.	37.5
1.04	17.30	57	18.30	196.	216.	37.4
1.04	17.30	58	18.30	165.	211.	37.3
1.04	17.30	59	18.30	139.	205.	37.2
1.04	17.30	60	18.30	115.	200.	37.1
1.04	17.30	61	18.30	76.	193.	37.0
1.04	17.30	62	18.30	61.	171.	36.9
1.04	17.30	63	18.30	50.	163.	36.8
1.04	17.30	64	18.30	41.	142.	36.6
1.04	17.30	65	18.30	34.	129.	36.7
1.04	17.30	66	18.30	26.	117.	36.6
1.04	17.30	67	18.30	23.	107.	36.6
1.04	17.30	68	18.30	19.	98.	36.4
1.04	17.30	69	18.30	15.	89.	36.5
1.04	17.30	70	18.30	13.	80.	36.4
1.04	17.30	71	18.30	11.	72.	36.4
1.04	17.30	72	18.30	9.	65.	36.3
1.04	17.30	73	18.30	7.	58.	36.3
1.04	17.30	74	18.30	6.	52.	36.2
1.04	17.30	75	18.30	4.	46.	36.2
1.04	17.30	76	18.30	3.	41.	36.2
1.04	17.30	77	18.30	3.	36.	36.1
1.04	17.30	78	18.30	2.	32.	36.1
1.04	17.30	79	18.30	2.	28.	36.1
1.04	17.30	80	18.30	1.	25.	36.0
1.04	17.30	81	18.30	1.	22.	36.0
1.04	17.30	82	18.30	1.	19.	36.0
1.04	17.30	83	18.30	0.	17.	36.0
1.04	17.30	84	18.30	0.	15.	36.0
1.04	17.30	85	18.30	0.	13.	36.0
1.04	17.30	86	18.30	0.	11.	36.0
1.04	17.30	87	18.30	0.	10.	36.0
1.04	17.30	88	18.30	0.	9.	36.0
1.04	17.30	89	18.30	0.	7.	35.9
1.04	17.30	90	18.30	0.	6.	35.9
1.04	17.30	91	18.30	0.	5.	35.9
1.04	17.30	92	18.30	0.	4.	35.9

1.02	22.30	93	40.50	0.	9.	143.	35.9
1.02	23.00	94	41.00	0.	3.	143.	35.9
1.02	23.30	95	41.50	0.	3.	143.	35.9
1.03	0.00	96	42.00	0.	2.	143.	35.9
1.03	1.00	97	42.50	0.	2.	143.	35.9
1.03	1.30	98	43.00	0.	2.	143.	35.9
1.03	2.00	99	43.50	0.	2.	143.	35.9
1.03	2.30	100	44.00	0.	1.	143.	35.9
1.03	3.00	101	44.50	0.	1.	143.	35.9
1.03	3.30	102	45.00	0.	1.	143.	35.9
1.03	4.00	103	45.50	0.	1.	143.	35.9
1.03	4.30	104	46.00	0.	1.	143.	35.9
1.03	5.00	105	46.50	0.	1.	142.	35.9
1.03	5.30	106	47.00	0.	0.	142.	35.9
1.03	6.00	107	47.50	0.	0.	142.	35.9
1.03	6.30	108	48.00	0.	0.	142.	35.9
1.03	7.00	109	48.50	0.	0.	142.	35.9
1.03	7.30	110	49.00	0.	0.	142.	35.9
1.03	8.00	111	49.50	0.	0.	142.	35.9
1.03	8.30	112	50.00	0.	0.	142.	35.9
1.03	9.00	113	50.50	0.	0.	142.	35.9
1.03	9.30	114	51.00	0.	0.	142.	35.9
1.03	10.00	115	51.50	0.	0.	142.	35.9
1.03	10.30	116	52.00	0.	0.	142.	35.9
1.03	11.00	117	52.50	0.	0.	142.	35.9
1.03	11.30	118	53.00	0.	0.	142.	35.9
1.03	12.00	119	53.50	0.	0.	142.	35.9
1.03	12.30	120	54.00	0.	0.	142.	35.9

PEAK OUTFLUX IN 3/4 IN. 10.00 INCHES

PEAK	24-HOUR	TOTAL VOLUME
3/4 IN.	450.	58328.
1.00 IN.	14.	1052.
1.00 IN.	2.51	5.51
1.00 IN.	100.00	100.00
1.00 IN.	2410.	2410.
1.00 IN.	2973.	2973.

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